Materials & Methods®

THE MAGAZINE OF MATERIALS ENGINEERING

VOLUME 31, NUMBER 5 — MAY 1950

Published monthly by Reinhold Publishing Corporation, 330 West 42nd St., New York 18, N. Y., U. S. A. Ralph Reinhold, Chairman of the Board; Philip H. Hubbard, President; H. Burton Lowe, Executive Vice President; F. P. Peters, Vice President and Secretary; W. P. Winsor, Vice President; G. E. Cochran, Vice President; J. G. Belcher, Vice President; Francis M. Turner, Vice President. Price 50 cents a copy. Payable in advance, one year, $2.00; two years, $3.00; three years, $4.00; five years, $5.00 in U. S. and U. S. Possessions and Canada. In all Latin American countries: one year, $10.00; two years, $16.00; three years, $20.00. All other countries: one year, $15.00; two years, $25.00; three years, $30.00. (Remit by New York Draft.)

Reentered as second class matter Nov. 14, 1945, at the Post Office at New York, N.Y. under Act of March 3, 1879.

Established in 1929 as Metals and Alloys.

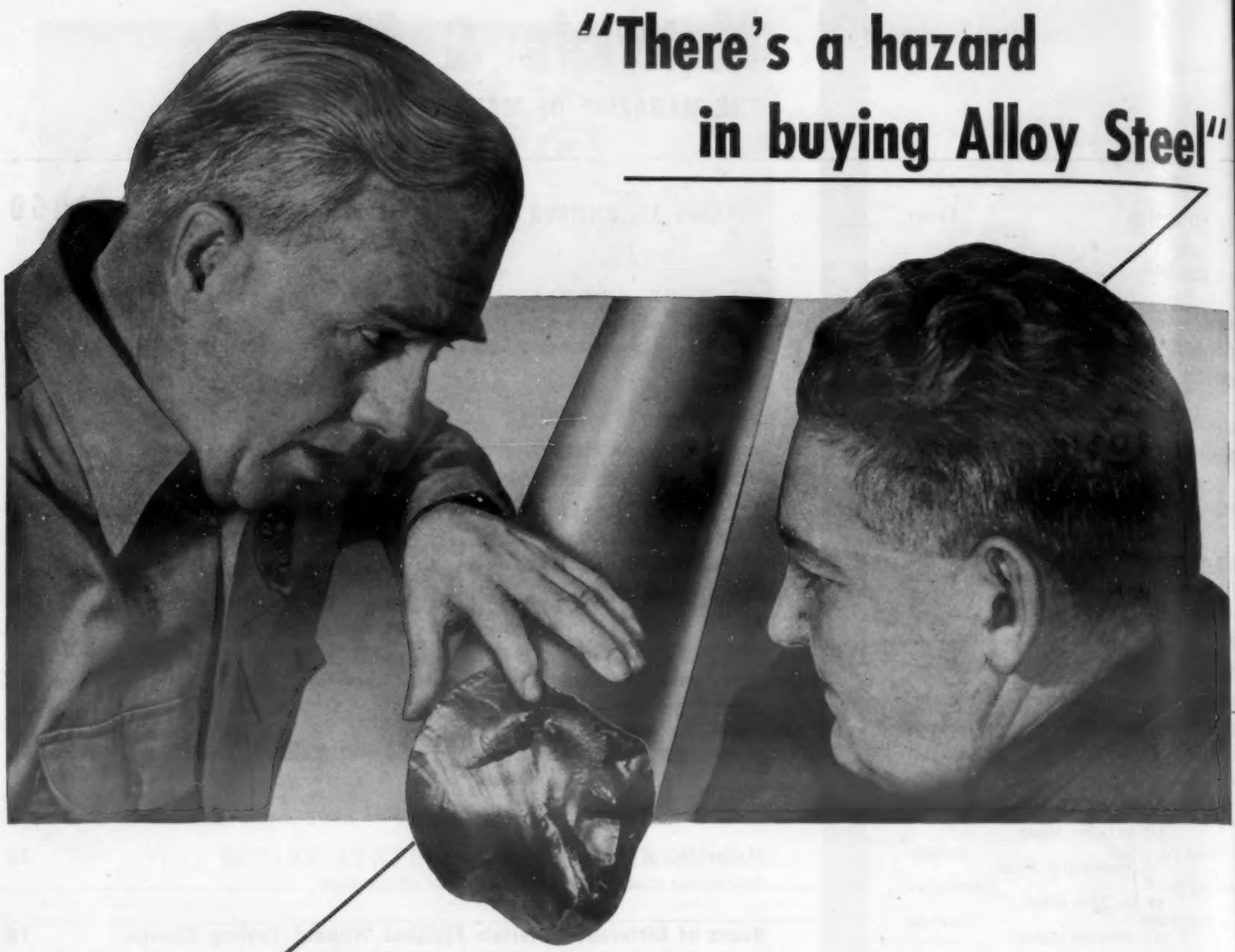
FEATURE ARTICLES

MATERIALS & METHODS MANUAL NO. 59

ENGINEERING FILE FACTS

DEPARTMENTS

NEXT MONTH: Gray Iron Crankshafts . . . Meaning of Tensile Properties . . . New Method of Laminating Glass Fibers . . . Aluminum-Magnesium Casting Alloy . . . Induction Brazing and Soldering . . . Plating . . . WIRE AS AN ENGINEERING MATERIAL (Materials & Methods Manual No. 60)



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The Materials Outlook

Business is still highballing on a clear track, despite after-effects of the coal stoppage and the continued Chrysler strike. . . . Consumer and industrial buying is holding at high levels, and in the aggregate, manufacturers have added to their backlogs of unfilled orders. . . . Many of the heavy industries are currently in a better position than they were at the beginning of the year. . . . Steel, copper and zinc, widely-used and therefore useful barometers, are in strong demand; and all kinds of business related to housing, including building materials, household appliances, and fixtures are under heavy pressure to meet demand. . . . Current construction activity and contract awards exceed anything ever before known at this time of year. . . . Thus, the closing months of the first half find most industrial activity exceptionally well-fortified. . . . Forecasters are even cautiously pushing their prognostications of continued activity out to the end of the current year . . . and the surprising thing about it is, that there doesn't appear to be anything in view to prove them wrong.

Inconel and Monel are enjoying widespread use in an ever-increasing field of applications, primarily because of the heat resistance and corrosion resistance they offer. . . . As an example, more and more nameplates are being made from these nickel alloys to assure legibility throughout a product's service life despite corrosive fumes, moisture, heat, and rough handling. . . . Add other little-known applications: The skirt-like, free moving flaps that cover the gap between the front and rear sections of cowlings on modern airliners' radial engines. . . . These flaps often wear badly due to rubbing against rear cowling sections. . . . One western airline has eliminated this bugaboo by riveting strips of Inconel sheet to both the flaps and cowlings.

And speaking of nickel alloys, the old-fashioned milk can is currently appearing in a new garb. . . . Now made from chromium-nickel stainless steel, these dairy-standbys are more than 24% lighter in weight than their conventional forebears. . . . They clean easier, have twice the life, and require no re-tinning . . . but the same old cows are still being used.

Steel, the behemoth of industry, appears to be almost fully recovered from its setbacks of last fall. . . . Shipments during late winter and early spring months to most industries were lighter than the same period a year ago. . . . But six industries in the past few months have received heavier shipments than they did in early '49. . . . These six are: automotive; oil and gas; containers; makers of bolts, rivets and screws; manufacturers of contractors' products such as plumbing and hardware; and a group covering furniture, office supplies and sporting goods. . . . This, in a general measure, is indicative of the current national scene, economically speaking. . . . The automakers are still steel's biggest customer, but their position is continually being challenged in aggregate by the jobbers and dealers who serve the multitude of small business enterprises scattered across the nation.

Copper, another material considered a mainstay in our industrial economy, is being squeezed--and hard. . . . Current demand from construction and consumer goods categories, coupled with substantial purchases for government stockpil-

(Continued on page 4)

The Materials Outlook *(Continued)*

ing, have combined to lift the price a cent a pound. . . . And even with this price rise, the pressure isn't off. . . . Current industry thinking is split over proposals to continue the suspension of import duties on foreign copper for the next couple of years. . . . Producers solely dependent on U. S. sources want the tariff reimposed. . . . They cite the closure of marginal mines which aided supply when prices climbed above the 20-cent level. . . . On the other hand, producers with foreign copper properties and many domestic fabricators want the suspension continued. . . . They point out that Canadian, Chilean and Mexican copper for years acted as a stabilizer to domestic prices . . . and the Government, that is, the Treasury, Commerce, State and Interior Departments, the Budget Bureau, Munitions Board, and Tariff Commission agree with them. . . . So, it's anybody's fight . . . but demand still climbs.

Ceramics often go unnoticed in the hurly-burly that accompanies the more widely used engineering materials, but for usefulness and importance they should not be overlooked. . . . Their resistance to deformation and warping; non-expansion and lack of deflection under load; non-magnetic, sweat-resistance and ability to withstand corrosion combine to provide an ideal material for certain applications. . . . Latest of these uses is in toolrooms and inspection departments as a surface plate. . . . In such applications, ceramics are found to afford high wear resistance and at the same time provide a surface flat to 0.0001 in. . . . Other growing fields of ceramics applications include textile machinery grides, electrical insulators, heating apparatus, and the like.

Magnesium is pulling hard in the light metals race, and the results are beginning to tell. . . . Latest additions to the crew are magnesium-zirconium alloy castings. . . . These are fine grained and have high strength, excellent fatigue resistance, improved compressive yield strength, and are relatively insensitive to notch effect. . . . We should be hearing plenty more about these newcomers soon.

Among the newest plastics developments is a phenolic resin compound formulated specifically as an insulation coating for electrical parts. . . . Supplied in powdered form, material is actually a mixture of phenol-formaldehyde thermosetting resin and an inert filler. . . . Powder and suitable solvents are mixed and dipping process is utilized. . . . Coatings are air dried and baked at 300 to 325 F to achieve excellent dielectric strength, and good resistance to salt spray. . . . Most useful for resistors, condensers, coils and capacitors, etc.

And speaking of phenolics, a new mineral-filled phenolic molding compound featuring excellent heat resistance, exceptionally good finish, extremely fast cure, and a relatively low specific gravity has recently been developed. . . . New material has good strength characteristics and suitable for molding around inserts. . . . Molded test pieces, baked for 24 hr. at 450 F are stronger after testing than before and retain high-gloss finish. . . . After 200 hr. at same temperature, surface is still relatively unimpaired. . . . Intermittent exposure to even higher temperatures is equally safe.

Recent advances in methods of applying metallic and nonmetallic coatings to gray iron castings have revolutionized application of iron castings. . . . Coatings of any desired metal can be produced by molten metal spraying; dipping the castings in molten metal; heating in contact with molten metallic salts; electroplating using improved techniques; or deposition of the required surfacing metal by oxyacetylene or arc welding methods. . . . Nonmetallic coatings, including organic and inorganic materials, are best applied by spraying, brushing or dipping, followed usually by suitable baking or firing treatments. . . . Properly coated castings exhibit immunity to the severest corrosive, wear and heat conditions.

News Digest

Survey Shows Wide and Varied Use of Stainless Steels

The use of stainless steel in industry has increased tremendously during the past decade. At first specified only where particularly tough corrosion problems were encountered, stainless is now called upon wherever good strength characteristics combined with long life in corrosive environments are desired.

This increase in the use of stainless can be explained by a number of factors, but perhaps the most important of these is increased knowledge of the properties, and especially the fabrication characteristics, of the various grades of stainless steel. Even this information, however, has never been organized adequately for the materials specifier; and it is in an attempt to remedy this situation that MATERIALS & METHODS publishes its comprehensive Manual No. 59 on "Stainless Steels—Their Selection and Application" (p. 83) in this issue.

Where Stainless Is Used

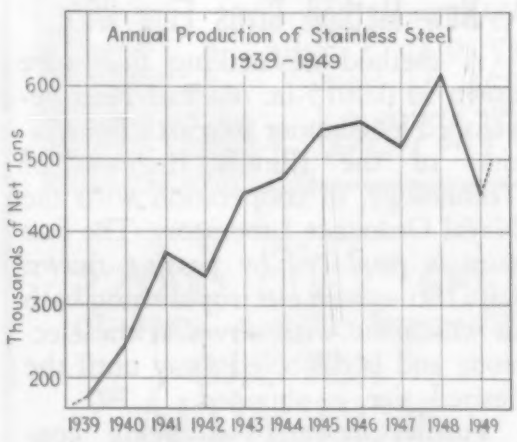
Of more limited usefulness, but probably of equal interest to materials engineers, is some information on the ultimate destination of this country's mounting stainless production. About a year ago, the M&M Market Research Dept. conducted a survey to determine the extent to which stainless steel was being used in industry. Questionnaires were mailed to M&M subscribers in industrial plants manufacturing the following products:

- Automotive products and parts
- Agricultural equipment
- Heavy machinery and machine tools
- Electrical equipment and appliances
- Building equipment and products
- Ordnance
- Aircraft, engines and parts
- Railway equipment and rolling stock
- Light machinery, business machines and instruments
- Hardware, cutlery and tools
- Chemical, petroleum and food processing equipment
- Ships, boats and marine equipment
- Fine metalware, jewelry and novelties

The questionnaire produced a 19% response.

Market Survey Results

The results indicated that, at the time of the survey, about 88% of the plants covered used stainless steel in fabricating their products. This average figure is exceeded in seven industries; namely, marine, aircraft, processing equipment, electrical, ordnance, and light and heavy machinery. The lowest proportion of stainless steel users, exactly 50%, was found among the fabricators of agricultural equipment. The validity of these results, of course, rests upon the not unreasonable assumption that the plants represented by M&M subscribers are a fair cross-section of the industries covered, and upon a percentage of returns generally considered adequate in surveys of this type.



This graph emphasizes the upward trend in stainless steel application. The drop in 1949 can be attributed to the steel strike. (Data furnished by the American Iron & Steel Institute)

The most popular forms of stainless steel, according to the tabulation, are sheet, bar, strip and tubing, in that order. Less widely used are wire, castings, plate, forgings and stainless-clad materials. It should be pointed out, however, that this order of popularity is based only upon the proportion of plants using the particular forms, not upon relative tonnages. Thus, it is quite likely that stainless castings, forgings and plate surpass wire on a tonnage basis.

What Forms Are Used

Nor does this rating of forms apply to all industries; there are a number of significant deviations which should be noted. For instance, the most important form by far in the automotive industry is strip. In the processing equipment industry, on the other hand, strip requirements are much lower while castings and stainless-clad materials are used much more frequently. In the aircraft industry, wire ranks even with strip; wire requirements are also high in hardware. Forgings exceed castings in aircraft, railway, ordnance and construction equipment. And high plate requirements are found in marine, railway and ordnance equipment.

From the figures obtained in the survey, it is also possible to indicate to some extent the industries in which each stainless form plays its proportionally most important role. Again, the limitations involved in translating

News Digest

number of users into tonnages must be recognized. But the following ratings should provide a general indication of some interest.

Each Form Has Its Place

Highest proportional demand for stainless sheet is in aircraft and railway applications, with ordnance, construction, agricultural and electrical equipment also fairly high. Bar stock is of most importance in ordnance, but of considerable importance also in aircraft, chemical and marine equipment, as well as heavy and light machinery. Applications for strip are found most frequently in the automobile and railway industries, although this form is also quite important to the electrical, light machinery, hardware, construction and marine industries. Stainless tubing is most used in aircraft and ordnance, but finds important application in chemical, agricultural, railway and marine equipment.

Stainless castings are of most importance in processing equipment, and they are used somewhat less in building ships, aircraft and heavy machinery. The importance of plate in ordnance and marine applications has been mentioned previously; this form has somewhat lesser importance in processing equipment, heavy machinery and aircraft. Stainless forgings are used most often in aircraft, ordnance and railway equipment, with lesser application in processing equipment, heavy machinery and railway equipment. Stainless-clad materials are of most importance in processing equipment, but also play an important part in the ordnance, railway, marine and heavy machinery industries.

Non-Destructive Testing to Highlight ASTM Meeting

A symposium to acquaint engineers and management with the advantages and uses of non-destructive testing will be one of the highlights of the 53rd Annual Meeting of the American Society for Testing Materials to be held the week of June 26 in Atlantic City, N. J. Other symposiums will be held on "Effect of Sigma Phase on the Properties of Metals at Elevated Temperatures" and "Corrosion and Erosion of Gas Turbine Materials," as announced earlier.

The non-destructive testing meeting will be held June 27. Sponsored by ASTM Committee E-7 on Non-Destructive Testing, the one-day conference will have as its theme "The Role of Non-Destructive Testing in the Economics of Production."

Six papers will be presented in two sessions. The first two papers will be of an introductory nature, one covering the basic principles underlying the important non-destructive test methods, and the other discussing typical discontinuities revealed by non-destructive testing. The remaining four papers will deal with the use of non-destructive testing for castings inspection, weldments inspection, wrought products inspection, and for special inspection problems.

Testing methods to be covered include radiography, ultrasonics, magnetic particle and liquid penetrant inspection, and magnetic analysis.

New Method Gives Fine Wire

A method of making fine wire down to 0.0015-in. dia. has been developed by Armour Research Foundation of the Illinois Institute of Technology, in cooperation with the Naval Ordnance Laboratory. The fine wire is produced by passing drawn wire through an electropolishing bath in which the wire serves as the electrode and is dissolved away until the desired size is obtained.

Further research is being conducted on the process, as the fine wire is expected to be useful in developing more compact electronic equipment and more delicate scientific instruments.

Profile Readings Allow Customer to Specify Casting Surface Finish

A method of establishing standard specifications for surface finishes on castings was proposed by H. H. Fairfield and James MacConachie in the *American Foundryman* (Feb. 1950).

Although a rough casting may be as useful as a smooth one, it has less appeal to the buyer. For a great many buyers of castings, the appearance of the skin is the deciding factor. Furthermore, castings which are highly stressed, such as aircraft components, will have fatigue life dependent upon the smoothness of the castings. Hence, the advantages to both pourer and user if castings could be supplied to meet surface smoothness standards.

Type of Metal	Normal Roughness Values		
	Smooth	Average	Rough
Aluminum	0.25	0.50	1.0
Brass	0.50	1.0	2.0
Iron	1.0	2.0	4.0
Steel	2.0	4.0	8.0

For measuring the finish, the authors propose use of the procedure already developed for machined surfaces. From 25 to 50 profile readings are taken in a straight line at 0.02-in. intervals across the casting surface. From these measurements, the median reading is determined; then the standard deviation of the valleys from the surface is determined.

Types of finishes found on castings range from 0.25 to 10.0, measured in deviations of 0.001 in. The accompanying table gives a tentative estimate of the type of finish normally obtained on castings of different alloys.

The prospective user of the castings could establish the finish desired by specifying the maximum deviation desired. The producer could then compare his castings visually against a set of measured surface finish specimens to determine whether the specification was being met.

CORRECTION

Because of faulty translation, the scrap percentage in the French hot extrusion process for steel (MATERIALS & METHODS, Mar. 1950, page 58) was listed as 0.35%. This figure should be 3.5%.

Plastics Show Features New Products, Processing Methods

The annual Plastics Exposition, held on Chicago's Navy Pier Mar. 28-31, showed advances in the formulating of many of the standard plastics compositions, and a broadening of applications. Just how definitely plastics have established themselves in many fields where they were only incidental materials 10 or 20 years ago is shown by reports from industry. Today three of every five raincoats made are of vinyl plastics. Approximately half of last year's phonograph records were made of plastics vinyl or styrene types. Refrigerators take an increasingly large amount of plastics per unit, using both thermosetting and thermoplastic types. About 90% of the shower curtains and 30% of the garden hose produced today are made of plastics materials, mostly vinyls. Automobiles use plastics chiefly for ornamental parts and for adhesives, but upholstery and small mechanical parts are taking larger quantities yearly. Overall, the total output of plastics has risen to five times the tonnage of ten years ago, and is now nearly equal to the annual tonnage of aluminum produced in the United States.

Electrical Plastic

The Polychemicals Dept. of E. I. du Pont de Nemours & Co., Inc., illustrated the expansion of its newest plastics material, Teflon, into the electrical field as an insulating tape capable of withstanding continuous exposure to temperatures in the 500 F range. The tetrafluoroethylene polymer has excellent high-frequency insulating properties, combined with extremely high chemical resistance. Extruded insulations were shown also.

Nylon, which has become a generic name for the polyamide resin developed by du Pont, is expanding rapidly as a molding material. Its low-friction properties make it useful in such applications as bearings, cams, guides and small gears. The narrow range in temperatures between the softening point and the point at which discoloration occurs requires adaptation of the molding procedure for most formulations, but slight changes in the injection nozzle will usually be satisfactory.

Polyethylene applications were featured by both du Pont and Bakelite, and included such industrial items as casings for high-frequency coils, extruded insulation for line wire, chemical piping, and supported coatings. The fact that the material is flexible without the addition of a plasticizer continues to stimulate its use as a packaging material for foods and medicinals, cosmetics and toiletries.

News Digest

Solution Coating Resin

B. F. Goodrich Chemical Co. introduced an improved high-molecular-weight polyvinyl chloride that features easy processing in combination with the good stability and physical and electrical properties of the high-weight polymer. Milling time may be 25 to 50% lower with the new formulation. Another new resin that offers valuable properties is the vinyl-vinylidene chloride copolymer that is directly soluble in such aromatic solvents as toluene and xylene, even up to 50% solids content. Solution coating of paper, foils and fabrics can be done economically with this resin. Another new product was a plasticizer for vinyls and other resins designed to improve their low-temperature properties without imparting

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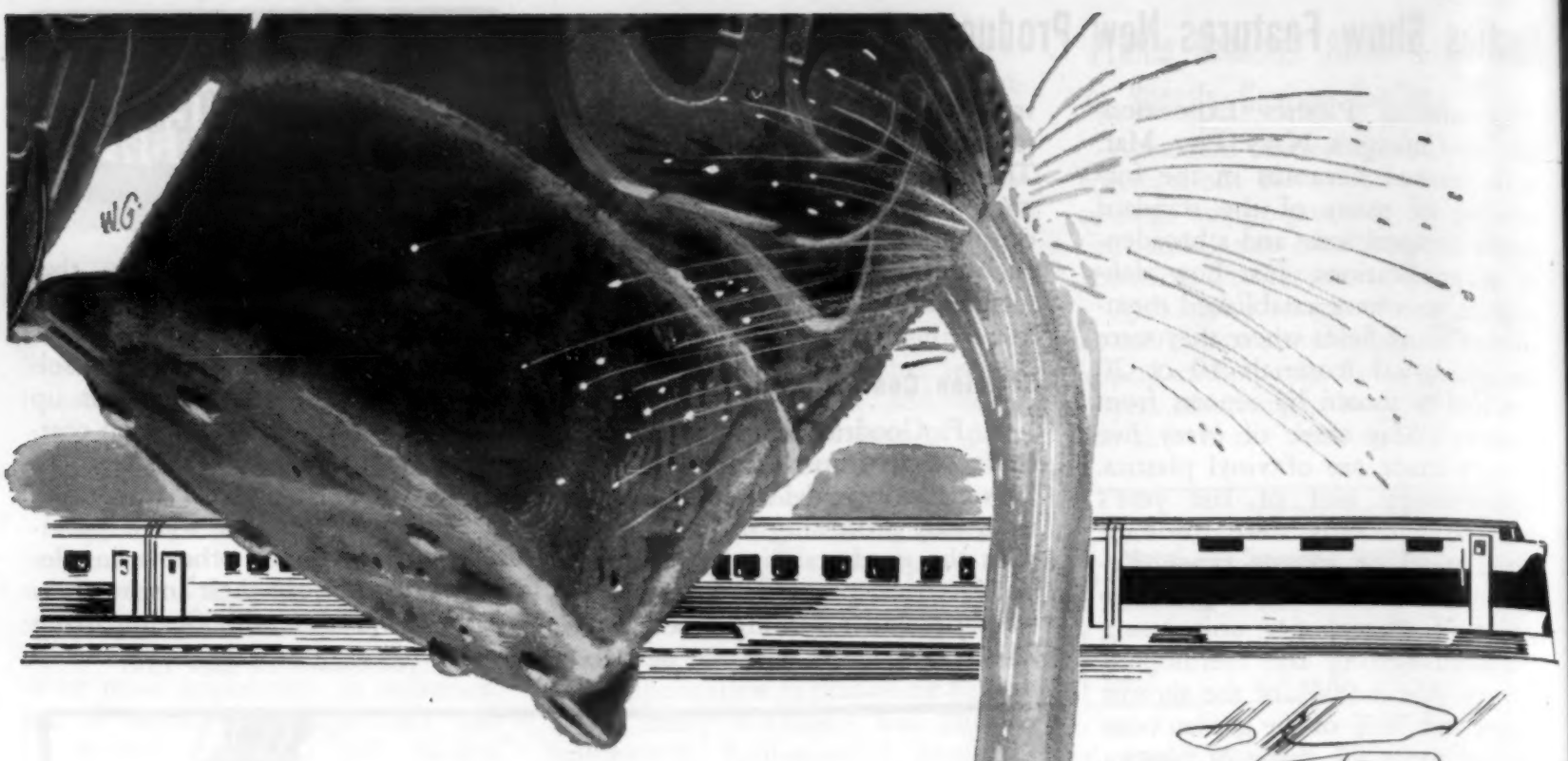

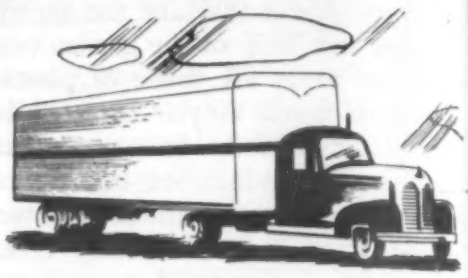

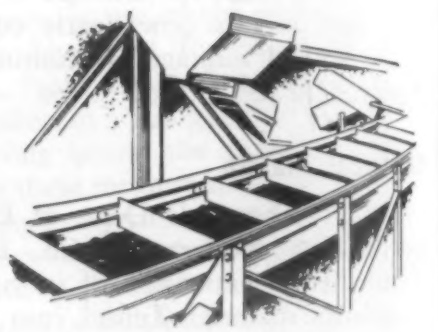

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Ultimate Strength (psi)	73,000	66,000
Elong. in 8" (%)	25	25
Endurance Limit		
Fatigue Strength (psi)	49,000	33,000
Impact Resistance (Charpy Impact—ft. lbs.) Temperature		
80° F	55	36
32° F	43	33
0° F	36	26
—25° F	34	6
—50° F	30	2

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Metals and Refractories Combined in High-Temperature Structural Parts

by JOHN B. CAMPBELL, Associate Editor, Materials & Methods

Published here for the first time is an up-to-date summary and objective appraisal of those new high temperature materials known variously as cermets, ceramals or metal-ceramics.

• THE GROWING IMPORTANCE of rockets and jet aircraft in both peace and war has raised an urgent materials problem. Essentially, the problem is one of developing structural materials which can withstand service temperatures in the range from 1800 to 2400 F and possibly even higher. Operating temperatures in this range would make possible tremendous improvements in thermal efficiency and, consequently, in the specific fuel consumption of gas turbines.

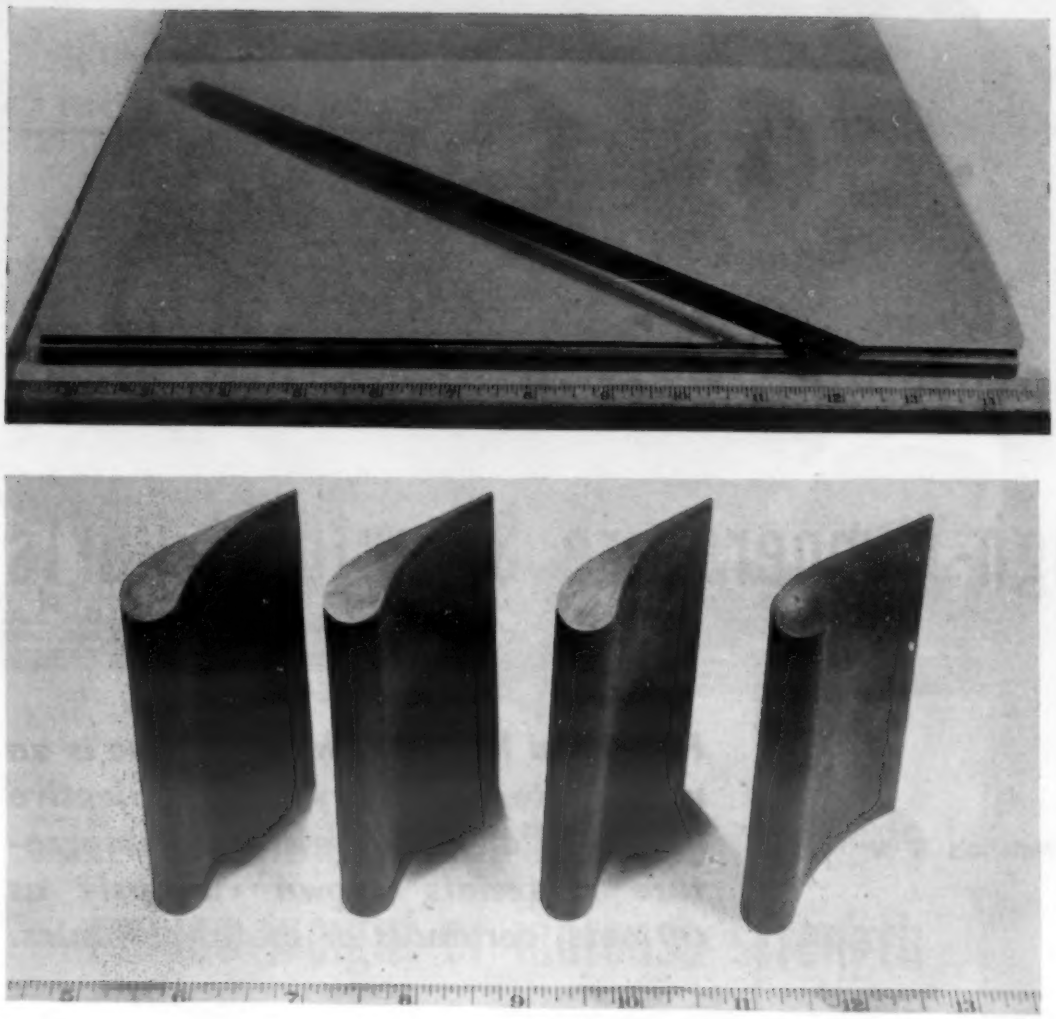
High-temperature alloys now used for gas turbine applications are relatively short-lived at temperatures as low as 1500 F because of high creep rates and lack of oxidation resistance. Even the high molybdenum, chromium and tungsten alloys now under development are not expected to extend the practical temperature limit beyond 1800 F, although use of air or liquid cooling appears to offer some promise for certain applications.

This materials problem was recognized early in the last war, when it was accentuated by the need for conserving such vital and scarce elements as nickel, cobalt, tungsten and columbium. It was then that ceramic coatings were applied to low-carbon steels for high temperature use. Since the war there has been much interest in the possible use of structural ceramics for gas turbine components. Ceramics have perfect oxidation resistance and retain a high proportion of their room-temperature strength at high temperatures. However, they have almost no resistance to cracking caused by the thermal shock encountered in gas turbine operation.

Because of this important limitation, it was natural that attention should turn next to the development of metal-refractory combinations possessing some ductility and thermal-shock resistance, in addition to high refractory qualities. Most of these new materials are still very much in the early stages of development, where any available information remains on a somewhat theoretical level. Furthermore, much of the current work is being carried out under government wraps, and results of these investigations are classified. Nevertheless, a number of these materials, which have been imaginatively labeled "cermets," are now commercially available and it is possible to see what directions research is taking. This article will attempt to describe these various substances and their properties, and, to a certain extent, indicate their potentialities as engineering materials.

The so-called "cermets" can be described broadly as refractory metallic compounds combined with metals and fabricated primarily by powder metallurgy methods. More specifically, the compounds of most interest are oxides, borides, carbides, nitrides and silicides; but the limited amount of information available on nitrides and silicides makes it advisable to confine subsequent discussion to the first three groups. The most promising combinations at the present time appear to be aluminum oxide (alumina) with iron or chromium, zirconium boride with nickel, boron carbide with iron, and titanium carbide with cobalt or nickel.

These combinations are generally hard and brittle at room temperatures; many can be machined only with diamond tools. In density, high-temperature strength, oxidation resistance and thermal-shock resistance, they fall somewhere between the constituent metal and the refractory body. Furthermore, these properties can be varied widely by adjusting the ratio of the metallic and non-metallic phases, a process made fairly simple by powder metallurgy techniques. There is considerable speculation and disagreement on the bonding mechanisms involved in these combinations. It is clear, however, that the result is a group of materials having both metallic and non-metallic properties.



Top, extruded and ground rods made of cemented titanium carbide; bottom, experimental diaphragm blades. (Courtesy Kennametal, Inc.)

Imaginative minds have already complicated the nomenclature of these new materials. Such terms as "cermets," "ceramals," "cerametallics," and "metal-ceramics" have been rather indiscriminately applied to this entire group of materials, the implication being that they are combinations of metals and ceramics. These early designations are being joined by an ever-increasing number of trade names for specific combinations.

It is obvious that the three principal groups to be discussed in this article can be more precisely classified as oxide-metal, boride-metal and carbide-metal combinations. It is also apparent that the carbide-metals are nothing more nor less than cemented carbides, an old and respected family hardly in need of a more glamorous title. Terms such as "cermets" and "metal-ceramics," used to encourage anxious designers, might better be applied only to oxide-metals which are, in fact, combinations of ceramics and metals. If a general term for these new materials is necessary, use of "metalloid combinations"—literally, combinations having both metallic and non-metallic properties—might be more acceptable than extending the meaning of "ceramic" to include all materials which are neither metallic nor organic in nature.

Oxide-Metal Combinations

First attempts to use oxide-metal combinations for gas turbine blades are believed to have been made in Germany during the war. The Germans developed several compositions of alumina and iron which they called "Dug." Results of their experimentation have been verified in the intervening years, and much additional work has been done in this country on these and similar combinations.

Alumina itself is one of the most attractive ceramics from an engineering viewpoint. It has a tensile strength of about 38,000 psi. at room temperature; this value drops only slightly at temperatures up to 1830 F and, at 2200 F, tensile strength is still 20,000 psi. Compressive strength of alumina approaches 450,000 psi. at room temperature, falling to 70,000 psi. at 2200 F. Despite the high strength and oxidation resistance which this ceramic possesses at elevated temperatures, however, the material is extremely brittle and quite susceptible to thermal shock.

Addition of a metal such as iron to this ceramic produces, in effect, a compromise material. The high-temperature strength and oxidation resistance of the ceramic are reduced, but its ductility and thermal-shock resistance are measurably increased. An alumina-iron combination containing about 60% iron is approximately half as strong as alumina alone. Specimens containing at least 30% iron, on the other hand, can be heated to 1470 F and quenched in water or cold air without injury. Thermal conductivity of alumina-iron mixtures increases tremendously when iron content exceeds 50%; such high conductivity often raises special problems, particularly in connection with turbine blades. The optimum amount of iron in alumina-iron materials is believed to lie between 40 and 50%.

In general, standard powder metallurgy techniques are used in the fabrication of these oxide-metal materials. The metal and oxide grains, often temporarily bonded by wax, are milled together until optimum particle size is obtained. The mixture is then pressed in molds at pressures ranging from 10,000 to 100,000 psi., and the compact is sintered at temperatures from 2500 to 3000 F under carefully controlled atmospheres.

The exact mechanism of bonding is open to considerable doubt. Recent work at Ohio State University has shown that, although metals have no inherent tendency to wet alumina at temperatures below 3000 F, wetting and adhesion are developed as a result of combination between the alumina and the oxides of the various metal additions. This suggests that, rather than the highly reducing atmospheres first employed in sintering, it would be advantageous to use atmospheres of controlled oxidizing intensity; and, in fact, good results have been obtained by pre-oxidizing the metal powder surface and using a nearly neutral atmosphere in firing.

The most desirable additions appear to be those metals which have oxides of the same crystal form and nearly the same lattice parameters as the ceramic oxide and which form a continuous series of solid solutions with it. Retention of metallic properties by the sintered material, however, indicates that the metal consumed in the bonding phase must be a relatively small proportion of the metallic addition.

Alumina-iron is only one of many oxide-metal systems now under investigation. Other ceramics being

studied are beryllium oxide and zirconium oxide. Metallic additions being tested include cobalt, nickel, aluminum, beryllium, zirconium, chromium and copper. One combination developed at Ohio State which shows particular promise contains 70 alumina and 30% chromium.

Metal-Rich Oxide-Metals

Although oxide-metal investigations have proceeded from both ends of the scale, the emphasis has been on the addition of a metallic phase to a strong ceramic. The reason for this, of course, is the pronounced superiority of ceramics to metals in overall resistance to high temperatures. In addition, there is much to be gained in many prospective applications from the far lower density offered by the ceramic materials. Nevertheless, the only commercially available material of the oxide-metal type is an example of the metal-rich end of the scale. This metal-ceramic, produced by Haynes Stellite, is known as Metamic LT-1. Its composition is 70 chromium and 30% alumina.

Metamic LT-1 is strong, but brittle enough to break if dropped on a concrete floor. When it fails under stress, the fracture is completely brittle except at temperatures over about 2500 F or under prolonged stress above 1800 F. The material is also fairly sensitive to thermal shock, though much superior to most ceramics in this respect.

Tensile strength of LT-1 is about 17,500 psi. at 1800 F, 7000 psi. at 2200 F, and somewhat higher than 3000 psi. at 2400 F. In addition to retention of fairly good strength properties in this range, LT-1 has particularly good resistance to oxidation in air at temperatures up to 2200 F and resistance to combustion gases up to 2900 F. It also resists attack by molten steel and furnace slag, but is rapidly attacked by molten glasses and alkaline vapors at temperatures as high as 2600 F.

At the present time, Metamic parts up to 2-in. dia. by 18 in. long or 3-in. dia. by 3 in. long can be produced, with dimensions held within ±2%. A certain amount of warping and distortion must be expected, however, and this can be particularly serious in the case of long thin objects. Where closer tolerances are required, allowance must be made for finish grinding with abrasive wheels.

Grade LT-1 can be machined with tungsten carbide tools or, more slowly, with high-speed steel tools. A number of joining techniques are available; they include mechanical threaded joints, special Metamic screws and bolts, pressure welding and shrink-fitted joints. LT-1 can also be copper-brazed to steel. In some cases, complex shapes can be produced by joining sub-assemblies during the fabrication process. No fusion welding techniques have been developed as yet.

The fields of application being considered for the Metamics are illustrated best by a representative list of parts which have been slip-cast: thermocouple protection tubes; tubes for injecting gases into molten metals; split molds for permanent-mold casting of alloy rods; high-intensity burner nozzles; sand blast nozzles; deflection plates for molten slag; bolts for high-temperature apparatus; high-temperature rack and roller pinions; and small calcining vessels.

In addition, LT-1 has been tested in several parts of ram jets, including the Venturi-type nozzle, the flame holders and thermocouple tubes, where gas temperatures of 3000 F are encountered. The material is also being tested for turbo-supercharger blades and gas turbine nozzles. Although its high metallic content would suggest insufficient strength at these temperatures, early reports on test results indicate that Metamic LT-1 holds some promise for such applications.

Boride-Metal Combinations

Research in the field of boride-metal combinations is not nearly so far advanced, at least for publication purposes, as is the work on oxide-metal and carbide-metal materials. Nevertheless, significant results are being achieved in this field, particularly in the Navy-sponsored investigations at American Electro Metal Corp.

Earlier studies had shown the desirability of obtaining materials similar to cemented carbides in their refractory properties and high moduli of rigidity, but superior to the carbides in resistance to corrosion in oxidizing atmospheres. A logical starting point for such research was chromium boride, as it was relatively hard and exhibited good corrosion resistance; furthermore, it was commercially available, since it was being used with iron and nickel in hard-surfacing alloys. Although chromium boride, sintered with a metallic binder, was ultimately found unsuitable, chiefly because of the appearance of a liquid phase at 1900 F, some of the results of this investigation have an important bearing on the future of boride-metal combinations.

Both 70 nickel-30% copper and 60 nickel-40% chromium produced good bonds in chromium boride, but the most effective binder was commercially pure nickel. Optimum properties were secured for a composition analyzing 85 chromium boride and 15% nickel binder.

Attempts to cold-press compacts of powdered chromium boride and binder were unsuccessful when the boride content exceeded 75%, as extremely low densities resulted. Hot pressing at temperatures high enough to melt the binder, however, produced dense bodies having good physical properties. In hot pressing, a sufficiently high current is passed through the powder mixture in a graphite die to raise the temperature of die and mixture above 2700 F in 1 to 2 min. When the temperature is reached at which pressing is to occur, the current is stopped and pressing accomplished by hydraulic means. The carbonaceous atmosphere within the die and the short time involved make it possible to avoid oxidation without providing a special atmosphere.

Since these tests were carried out, only a limited amount of information has been forthcoming. Late last year the Office of Naval Research announced that a zirconium boride compound had been developed by American Electro Metal Corp. This material was said to have survived higher temperatures than any other material used in their experimentation.

It would be hazardous, at this point, to speculate on the actual properties of this zirconium boride material. However, the fact that zirconium boride alone has a melting point about 2000 F higher than chromium boride and 1700 F above that of alumina indicates that high refractory properties can be expected. Results of previous investigations, moreover, indicate that the actual composition of this material may approximate 85 zirconium boride-15% nickel, and that it is undoubtedly fabricated by hot pressing rather than more conventional powder metallurgy techniques.

Cemented Carbides

Cemented carbides as such need

little introduction here. Their usefulness as tool materials, resulting from their retention of strength and hardness at fairly high temperatures, has long been recognized. But the temperatures encountered in cutting operations do not approach those proposed for gas turbine power plants. At such temperatures, tool compositions consisting primarily of tungsten carbide oxidize rapidly, forming oxidation products which do not protect the remaining material. Furthermore, these tungsten carbide compositions have high specific gravities, ranging from 8.0 to 15.0.

Nevertheless, the carbides, because they are the highest-melting compounds known, have been an important field of investigation. The fact that titanium carbide has a higher melting point than tungsten carbide and, in addition, has a lower density than any of the other refractory metal carbides, led to consideration of this compound for high-temperature use. Titanium carbide had previously been used extensively for supplementing the properties of tungsten carbide in tool compositions. Cemented titanium carbides had also been developed previously, but such compositions appeared to have low strength and poor oxidation resistance. Recent work at Kennametal, Inc., however, has resulted in the development of a whole series of cemented titanium carbides, fabricated by powder metallurgy and possessing high strength and oxidation resistance. In these compounds, tremendous improvement in oxidation resistance has been achieved by replacing part of the titanium carbide by the high-melting tantalum and columbium carbides. The reason for the marked effects of such additions is not known.

The auxiliary metals used in these titanium carbide compositions are cobalt and nickel, the nickel being used at present only where special chemical resistance is needed. These two binders offer equal oxidation resistance, but cobalt seems to provide the better high-temperature strength. Most useful grade of the Kentanium series appears to be K138A, containing 20% cobalt as binder; this composition has better thermal-shock resistance than most of the other grades, in addition to the best strength properties obtainable at 2400 F.

Many of the properties of the Kentanium series have yet to be determined, but a few are listed in Table 1. Additional properties have been determined for some grades and give a fair indication of those to be expected from the remaining grades. Thus, the thermal expansion coefficient from 100 to 1200 F is about 4.5×10^{-6} per deg. F, thermal conductivity is about 18 Btu./hr./sq. ft./ft./F, and room temperature compressive strength is about 450,000 psi. Both thermal and strength properties are affected by the amount of auxiliary metal; room temperature strength increases with the amount of metal binder, but high-temperature strength is adversely affected. Electrical conductivity also varies with the amount of auxiliary metal, being about 4.0% of that of standard annealed copper for 20% cobalt and 1.9% for 10% cobalt.

A long-standing difference of opinion over the bonding mechanism in cemented carbides has been extended to these higher temperature grades. Thus, it is not certain whether the cemented carbides owe their properties primarily to the carbide or to the metallic phase; each contention can be supported by certain experimental evidence. It is apparent, therefore, that the exact nature of these high-temperature cemented carbides, in common with most other metalloid combinations, is not fully established at the present time.

Cemented titanium carbides have been found suitable for a number of applications, some of which are listed in the accompanying table. Potential applications are naturally limited by the fabrication methods which must be employed. Generally these materials can be extruded to form small-diameter rods and shapes and tubes up to 9/16-in. O.D. and 18 in. in length. They cannot be machined after sintering, although they can be ground with diamond wheels. They are just as susceptible as tool compositions to cracking from local overheating, however, and the same precautions taken for tool compositions must be observed. These compositions cannot be brazed by ordinary methods; furthermore, the temperatures at which they operate render present brazing materials useless. Welding is impractical because of

Table 1—Properties and Applications of Kentanium Oxidation-Resistant Grades

Grade	K138A	K139A	K140A	K141A	K150A	K151A
Composition, %*	TiC, 80 Co, 20	TiC, 95 Co, 5	TiC, 90 Co, 10	TiC, 70 Co, 30	TiC, 90 Ni, 10	TiC, 80 Ni, 20
Specific Gravity	5.8	5.4	5.6	6.0	5.6	5.8
Modulus of Elasticity (Room Temp.), Psi.	57.3×10^6	51.2×10^6	53.2×10^6	54.3×10^6	52.7×10^6	56.7×10^6
Transverse Rupture Str. (Room Temp.), 1000 Psi.	150.0	112.0	135.0	190.0	—	150.0
Hardness, Rockwell A	89.5	93.0	91.5	87.5	—	89.0
Relative Properties: High Temp. Strength Softening Temp. Thermal Shock Resist.	 Highest Medium High	 Lowest Highest Lowest	 Medium Medium Medium	 High Lowest Highest	 Medium Medium Medium	 High Medium High
Applications	Hot tube spinning tool. Extrusion dies for brass or bronze. Thermocouple protection tubes.	—	Molten metal thermocouple protection tubes. Resistance heating elements for electric furnace.	Hot working dies where severe shock encountered.	Same as K140A. Also resists attack by aluminum and glass.	Same as K138A. Also resists attack by aluminum and glass.

*** Titanium carbide figure includes unspecified amount of tantalum and columbium carbides.**

Adapted from data furnished by Kennametal, Inc.

cracking. These materials can be threaded, but other methods of mechanical holding are preferred wherever possible.

Of the various metalloid combinations developed so far, Kentanium grade K138A appears to be the most promising for gas turbine blades. In an attempt to determine the usefulness of Kentanium in high-temperature power plant operations, Kennametal engineers are now engaged in constructing a small gas turbine in which not only the blades, but also such parts as disk, nozzle vanes and box and combustion chamber liners will be fabricated from this material.

Another titanium carbide mixture which may prove useful is one containing about 10% molybdenum as a binder. In tests conducted by the National Advisory Committee for Aeronautics, this combination demonstrated better high-temperature strength than any other titanium carbide materials. Although its oxidation resistance was much poorer than that of cobalt-cemented titanium carbide, the N.A.C.A. tests did not include materials reinforced with tantalum and columbium carbides.

Still another carbide which has undergone extensive investigation is boron carbide, of special interest because it is the hardest substance produced by man. N.A.C.A. tests have shown that a sintered mixture of 64 boron carbide and 36% iron has a strength-weight ratio at 2400 F about 20 times that of 80 titanium carbide-20% cobalt, and twice that of the 90 titanium carbide-10% molybdenum mixture. The specific gravity of this combination is only 3.2 compared to 5.8 for the titanium carbide material. Unfortunately, the tests also indicated that the rate of oxidation was such that a protective coating would be required for continued operation above 1600 F. Since the addition of tantalum and columbium carbides has imparted so much oxidation resistance to cemented titanium carbides, it is interesting to conjecture whether similar results might not be obtained for cemented boron carbides.

Outlook for Tomorrow

The scope of potential applications for high-temperature materials has been indicated somewhat generally. In addition to blading, the most urgent requirements include materials for the interior of turbine engine tubes; for tailcones and tailpipes; for afterburner parts; for rocket combustion chamber liners and nozzles; for missile combustion chambers, guide vanes, reactors and warheads; for applications to supersonic air foils; and for other vital uses in jets, rockets and guided missiles.

Many of the metalloid combinations under development, and especially those now commercially available, have proved suitable for certain high temperature applications. It is safe to say, however, that the overall problem has not diminished appreciably. Although the use of K138A stator blades in production engines within the year has been forecast, not one of these metalloid combinations is believed suitable for use in gas turbine rotor blades at the present time. Even where the problems of strength, oxidation resistance and resistance to thermal shock have been overcome, important fabrication and cost problems remain.

Although cemented carbides appear to be the most promising of these materials for early application to gas turbine parts, the other metalloid combinations should not be overlooked. The tantalum and columbium carbides used to add oxidation resistance to the cemented titanium carbides are being obtained from tin extraction dross but, nevertheless, the generally critical supply of these additions must be considered in evaluating the usefulness of the cemented carbides. No such scarce alloying elements are required for the oxide-metal and boride-metal combinations. And there are many additional metallic compounds which have not yet been fully investigated. Just recently a series of "metal-ceramics" has been announced by P. R. Mallory & Co., Inc., but no details on these materials are yet available.

Furthermore, the metalloid combinations fabricated by powder metallurgy cannot justifiably be considered alone, as they will have to compete with many other types of processes and materials. Other methods of combining metal and ceramic phases are being investigated, including vapor impregnation and capillary intrusion of the molten metal into prefired ceramic bodies. Another technique consists of vaporizing metal and ceramic together and depositing the combination as a metalloid coating on a base material.

Much attention is being devoted to methods of producing ceramic coatings on metals, such as electrolytic methods, spraying, dipping, fusion, etc. Research is also being conducted on such materials as graphite and silicon carbide mixtures; fused alumina and silicon carbides; oxides, borides, carbides and nitrides without metal binders; carbonaceous materials with or without metallic powder additions and/or bonding materials; compounds of plaster of Paris, gypsum, graphite or carbon to provide cooling by chemical reaction; bodies of one, two and three constituent oxides; and ternary and quaternary oxide systems with complete liquid miscibility on melting.

It is impossible now to predict what materials will ultimately prove satisfactory for gas turbine and other high-temperature applications. It seems fairly certain, however, that no one material will prove suitable for all such applications. Even on the basis of strength alone, it is likely that no one material or combination will be found to possess the highest properties over any considerable temperature range. When the variables of oxidation resistance and thermal-shock resistance are considered, it becomes evident that eventually a whole series of materials will be evolved, each grade having optimum properties for certain conditions of service. Although there is no guarantee that metalloid combinations will prove the most effective types of high-temperature materials, enough research has been done to show that materials having the properties of both metals and nonmetals do have application under certain conditions of high temperature service. Some of them may be important engineering materials of tomorrow.

Acknowledgment

Much of the information in this article was furnished through the publications or personnel of the following organizations:

Air Materiel Command
American Electro Metal Corp.
Haynes Stellite Div., Union Carbide & Carbon Corp.
Kennametal, Inc.
National Advisory Committee for Aeronautics
New York State College of Ceramics
Office of Technical Services, U. S. Dept. of Commerce
Office of Public Information, U. S. Dept. of Defense

In addition, the author wishes to acknowledge the assistance of Norman L. Mochel, Westinghouse Electric Corp., in preparing this article.

New Fibrous Materials Suited for Many Engineering Uses

by R. A. ST. LAURENT, Vice President, Rogers Corp.

Duroids, a recently developed group of industrial fibre boards, are rigid, tough, and can be readily formed and fabricated.

● BROADLY SPEAKING, there are two major types of non-metallic sheet materials for use in product manufacture. One group consists of laminated plastics; the other is the wide group of fibre boards. Industry, up until a short time ago, has had to fill its need for fibrous parts within the framework of these sheet materials. The gap between the two groups is large and marked by a wide variation of characteristics between the materials at each level. Part of this gap has been filled by materials commonly known as vulcanized fibre.

Now a much more flexible condition prevails. A new class of industrial fibre boards—the Duroids—has been developed by Rogers Corp., Manchester, Conn., which helps to fill this gap between laminated plastics and existing fibre boards.

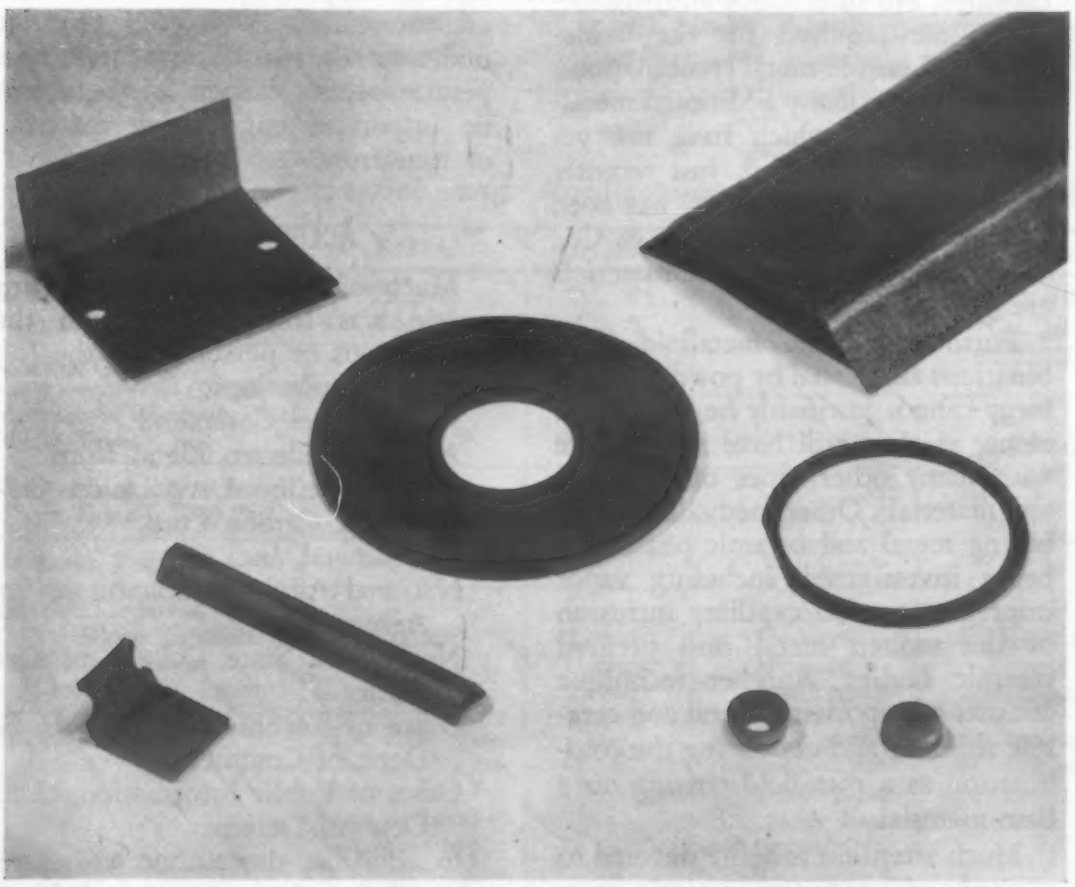
Types and Properties

Broadly defined, the Duroids have a cellulosic base with various combinations of resin binders. They are made in sheets on cylinder wet machines, then dried and densified. The standard sheet size is approximately 48 by 60 in. in gages ranging from 0.015 to 0.125. Because of the close interlocking of fibres within the ply and between the plies, the materials are homogeneous and appear to be solid. The color and surface pattern of Duroids varies, depending on the type. Rogers supplies the materials as sheet, or will fabricate component parts, prefaced by design assistance where desired.

As a group, the Duroids are characterized by the following properties: homogeneity, water resistance, toughness, high mechanical strength, stiffness and oil resistance. The wide scope and flexibility of these materials lie in the fact that it is possible to modify their characteristics readily to place emphasis on one or more of various mechanical, chemical and electrical properties—with possibly some sacrifice of other less important qualities. By varying component ingredients and manufacturing procedures, a Duroid or series of Duroids can be developed to meet special characteristics. The following is a list of properties which can be varied to suit application requirements.

1. Flexibility
2. Dielectric strength
3. Ability to bend, form, shape and draw
4. Low swelling after immersion in water
5. Retention of high mechanical strength after immersion in water (high wet strength)
6. Water absorption
7. Arc resistance
8. Fungus resistance
9. Heat-aging characteristics
10. Freedom from brittleness

As of this writing, there are seven series of Duroids in production. There is a mechanical group which includes Duroids 100, 200, 300 and 400. They are suited for such applications as backing for adhesive sanding disks, athletic protective equipment, golf bag bottoms, luggage and numerous other purely structural uses. Duroid 200 typifies the versatility of the new materials. It can be drawn,



Some typical forms that can be produced with Duroids. These materials can be bent, formed, drawn, punched, stitched and riveted.

formed and bent, is high in strength, and has good water resistance. In addition, it has good dielectric characteristics when dry and is employed for insulating parts.

Another series, Duroid 700, was developed especially for electrical applications and has been approved by Underwriters Laboratories as a replacement for vulcanized fibre. This series features a lower water absorption rate than the mechanical grades and maintains good dielectric strength when exposed to elevated humidities. Duroid 700 is utilized as insulation for such equipment as switches, motors, generators, transformers, radios, television sets and electronics devices.

Duroid 600 exemplifies the manner in which a material was developed to meet specific requirements with respect to performance and cost. The part involved required a minimum total swelling while actually immersed in water. Laminated phenolic was a satisfactory material from this standpoint, but it was much too costly, as considerable high cost worthless scrap was inevitable because of part design.

The Duroids excited interest because of their flexibility and because scrap could be salvaged. In developing the 600 series, Rogers had to formulate a new material and conceive a new method of handling it. The production program which resulted had two phases. In the first phase, the parts were fabricated from the Duroid material as it came from the machines, leaving scrap that could be reprocessed.

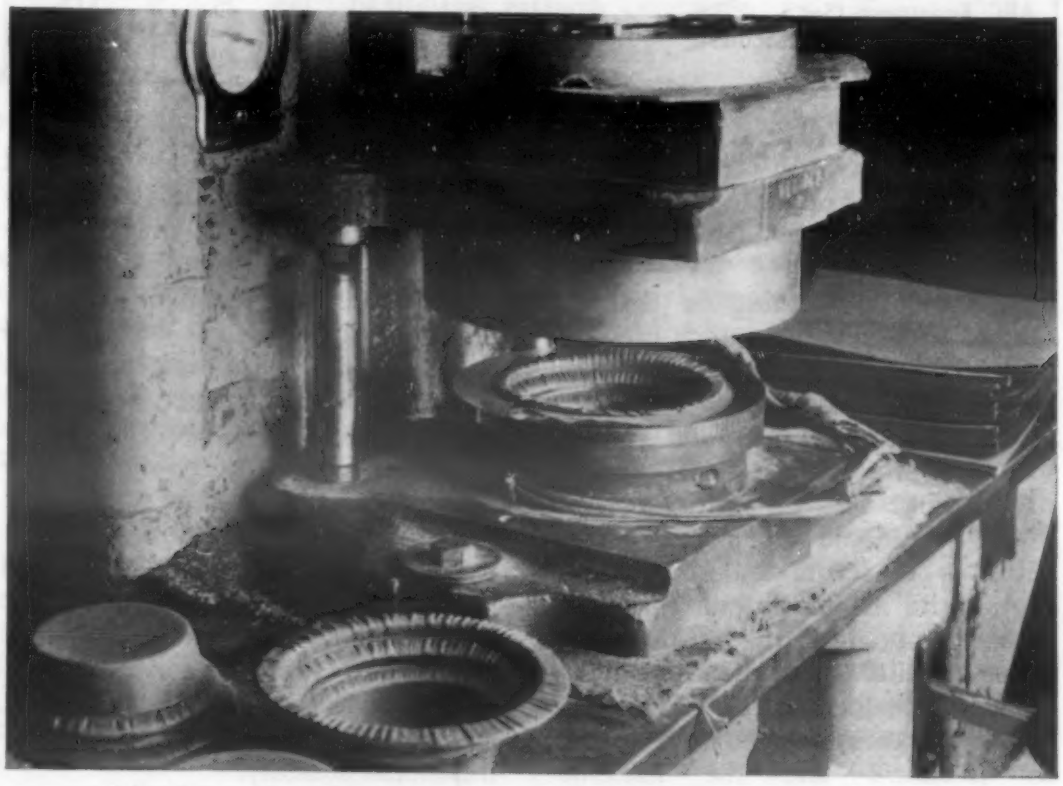
In the second phase, the material —now in the form of fabricated parts—was subjected to heat, which set up a chemical reaction in the Duroid and qualified it for the intended application. Reclaimable scrap could not be obtained after heat treating. Duroid 600 is now a standard series, offered for applications in which total low swelling and high scrap reclamation are essential.

The seventh series of Duroids is another type developed for a special purpose and which now is a standard material grade. Duroid 900—as this series has been designated—was formulated to meet the need for a material which could be employed as a gasket between two highly machined surfaces. Specifications for the material required that it have the surface and strength to function efficiently as a gasket between two machined surfaces joined with low torque applied to the fasteners. The gasket would be subjected to elevated temperature, hydraulic pressure and oil at high temperature.

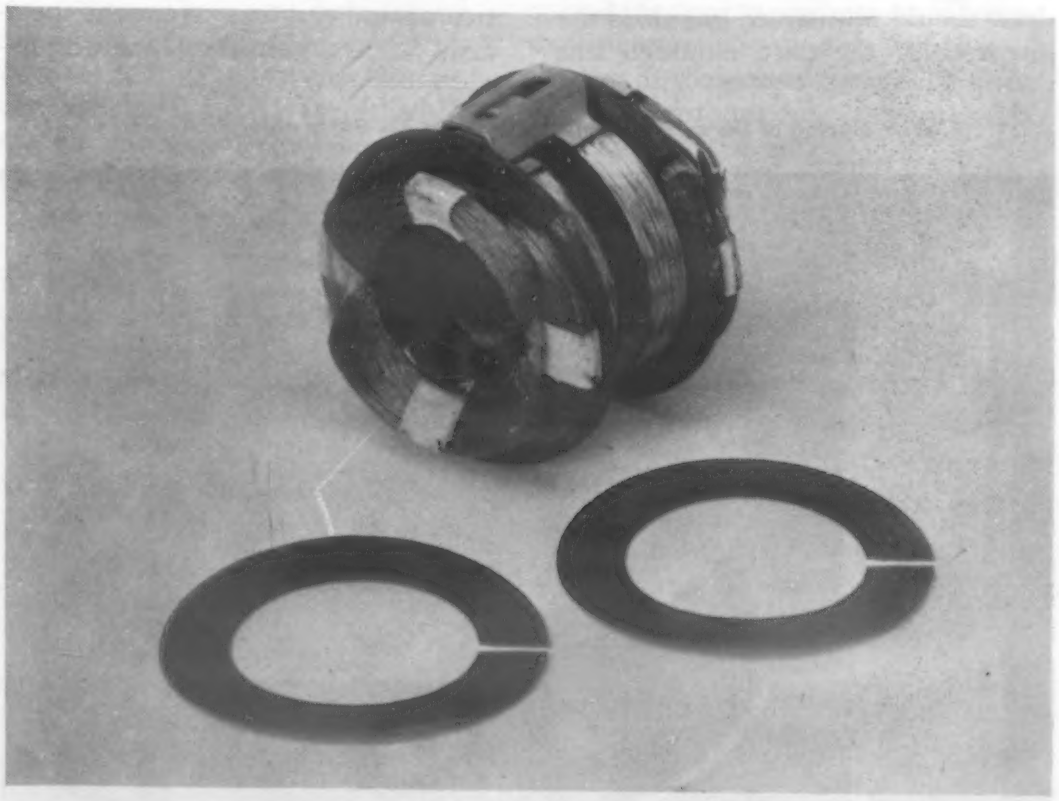
Additional Duroids are in the process of development to cope with the demand for special characteristics. Among them are a material with very high wet strength and another which is being formulated to meet extremely low water moisture absorption requirements.

Diecutting in all its forms is readily accomplished on all grades to close tolerances. Tolerances as high as ±0.010 in. can be maintained. They can be punched or blanked, slit or sheared. Steel rule dies and cutting equipment, full blanking or progressive dies on punch press equipment can be used. Duroids can also be stitched, stapled or riveted.

An important factor, from the standpoint of material cost of fabricated parts, is that most Duroids have reclaim value. Substantial savings in material costs can be realized



Deep drawing a Duroid insulating cup for an electric motor.



Duroid is being used as insulators for television coils. Two rings are used to a coil.

Typical Properties of Duroids Compared to Other Sheet Materials

	Duroid 200	Duroid 700	Laminated Phenolic	Elect. Press-board (Kaypar)
Thickness (In.)	0.062	0.062	0.062	0.062
Density (Gr./Cu. Cm.)	1.25	1.25	1.35	1.15
Weight (Gr./Cu. In.)	20.5	20.5	22.0	19
Tensile (Lengthwise), Psi.	25000	23000	14000	16000
Tensile (Crosswise), Psi.	8000	7000	12000	5600
Flexural (Lengthwise), Psi.	30000	26000	23000	—
Flexural (Crosswise), Psi.	16000	15000	20000	—
Compression Strength, Psi.	43000	41000	35000	—
Bursting Strength, Psi.	2200	2000	—	1600
Water Absorption (24 Hr.), %	60	50	4.0	120
Ash	0.75%	0.50%	—	.5%
Dielectric Strength (BD), VPM	500	500	700	250
Dielectric Strength (7%MC), VPM	200	400	—	225
ARC Resistance (Sec.)	75	130	25	115
Rockwell Hardness (R Scale)	85	70	—	—
Oil Resistance	Excellent	Good	Excellent	Poor

on such items as washers, gaskets, insulating inserts, and so on where waste assumes formidable proportions.

In drawing, forming or shaping Duroid parts, either a punch press or hydraulic press can be employed. The punch press is faster, but is limited in the depth of draw and in the forms it can accommodate. Hydraulic press fabrication is preferred if a dwell in the die under pressure is necessary to secure a desired form.

As with other fibrous materials capable of being formed, little actual draw is realized with the Duroids, of the type obtained in forming metals where the cross section is decreased in thickness and the material stretched. This factor imposes a definite limitation on the depth to which a part can be drawn. The usual yardstick applied is that the depth of draw should not exceed one-third the diameter of the part, although this limitation does not apply on small parts with diameters less than 1½ in. Here the ratio of draw to diameter can go as low as 1:1. In terms of absolute measurement, a draw depth of 1½ in. can be achieved on a ratio of draw to diameter of 1:3.

In common with other fibrous materials, the Duroids are affected by high and low humidity, and have a fairly high rate of water absorption, the degree being determined by the formulation. However, as mentioned previously, types are now available with relatively low water absorption. For certain applications, after-treatments, such as waxing or painting, are desirable to obtain greater dimensional stability.

Practically any type of finish can be applied to the Duroids. They can be impregnated, saturated or coated, depending upon the type of part treated and the type treatment specified. Waxes, varnishes, paints, phenolic resin coatings and rubber coatings can be sprayed or applied by dipping.

Wax dipping of Duroid parts imparts to them low water absorption rates.

Typical Applications

The following case histories illustrate the potentialities of the Duroids and the ways in which, because of their particular advantages, they were able to solve certain problems.

Structural Electrical Insulation—The problem here was to find a material with the desired dielectric characteristics and strength enough to stand a severe torque. The manufacturer not only required submission of the material to a torque test but to a drop test as well to determine impact resistance. The material was required to take these tests after being subjected to a temperature of 450 F for 5 min: A paper-base phenolic was used first, but because of excessive breakage on both torque and impact tests, it was discarded. Duroid 200 met both tests with margin to spare. Duroid was also less expensive than the phenolic material. The manufacturer not only realized a saving in initial material expense, but in rejection costs on an item whose production ran into the millions.

Flashlight Lens Gasket—This part was needed to protect the lens guard when the lens guard was screwed tightly onto the metal case. It had to have a thin wall section, 0.125 in., on one side and had to be bent upon insertion. Duroid 100 met requirements, its lack of brittleness permitting insertion without breakage. Besides providing the desired part, and eliminating rejection costs, Duroid contributed additional savings because of its reclaim value. In punching a part of this type, about 80% of the material used is normally scrap.

Electrical Fitting Insulation—In this instance, the manufacturer wished to replace, at lower cost, a phenolic fitting. A metal part was designed which required inexpensive but satisfactory insulation. Plastics such as polystyrene and nylon were tried, but, while they afforded ideal insulating qualities, they were too expensive for the purpose. Duroid, treated with a phenolic varnish to provide required resistance to humidity changes, enabled the manufacturer to put his new fitting on the market at low cost.

From the typical applications just described, it is evident that the inherent versatility of the materials adapt Duroids to a wide range of different uses.

Soft Grits Provide Low Cost Method for Blast Cleaning Metals

Grits from agricultural residues, such as corncobs, rice and nut shells, can be used in conventional blasting equipment for degreasing, removing welding scale, and cleaning metal surfaces prior to plating.

by T. F. CLARK and E. C. LATHROP,
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U. S. Department of Agriculture

• TROUBLESOME, AS WELL AS expensive, cleaning problems continually arise during manufacture and maintenance of many items, such as automotive and aircraft engines, electrical equipment, chemical and food processing equipment, and machine parts. Poorly-chosen cleaning methods can cause scrapping of parts and the loss of considerable number of man-hours. Furthermore, such methods might well account for expensive plant shut-downs. In many cases such losses can be minimized, if not eliminated entirely, by the use of soft grits in conventional sand-blasting equipment. The method is essentially foolproof, involves no toxic liquids or flammable solvents, and is four to ten times faster than older methods. Machine components cleaned by the soft-grit method require no additional machining or fitting for re-use.

Soft grits from corncobs were developed by the Northern Regional Research Laboratory for use by the Bureau of Aeronautics of the Navy for cleaning and salvaging aircraft engines during World War II. Cleaning action of the cob grits was further accelerated by the addition of rice hulls. This combination, after considering availability, first cost, period of usefulness, and operating efficiency, was adopted and widely used for cleaning airplane cylinders and pistons with no change in dimensions and no pitting action.

In addition to corncobs, several other types of agricultural residues, particularly the shells of nuts and fruit pits, are known to possess physical characteristics quite similar to those of cob grits. Of these, grits from apricot pit shells were used by the Army during World War II. Grits from coconut shells were produced and used by the Navy at some tropical stations. Recently grits from the shells of pecans, English and black walnuts, and peach pits have become available in commercial quantities, and presented below are the results obtained in a study of the efficiency and durability of grits from 11 of the more readily available materials used with and without rice hulls (see accompanying table).

The grits for this investigation were prepared by grinding the various shells in either a hammer mill or an attrition mill. The ground products were classified on vibrating screens to be essentially finer than No. 12 and coarser than No. 30 (U. S. Standard sieve sizes). Dust and low-density components were removed by aspiration. The corncob grits were commercially available materials furnished by a custom grinder. These were used as received, after screening and after air-separation. The mixtures of grits and rice hulls were in the proportion 9 to 5. This proportion was used in preference to the usual 7½ to 5 for cob-rice hull mixtures because of the greater density of the shell grits. All tests were conducted with conventional suction-type sand-blasting equipment, provided with compressed air at 90 psi.

Characteristics of Various Grits

The comparative useful life of the various grits was estimated by blasting the grits at right angles to the surface of a steel plate for 1 hr. Distance between the blast nozzle and the steel plate was 5 in. Loss of grits as fines and dust removed by the exhaust system was calculated from the material remaining in the blasting booth at the end of the 1-hr. period. Change in particle size of grits, determined by sieve analyses before and after blasting, supplemented the observations on fines and dust removed. Durability, as indicated by the amount of dust and reduction in the quantity of No. 30 grits, is shown for 11 different grits in the table.

Determinations for cleaning efficiency or abrasive character were made by blasting the grits or the grit-hull mixtures against steel panels coated with six layers of baked-on resin-base paint until the paint film was penetrated. In these tests the blasting nozzle was held 3 in. from the panels. The time, in seconds, required for penetration was considered the measure of cleaning efficiency. Results of these tests for the 11 grits with and without rice hulls are also presented in the table.

Grits selected for a given cleaning problem must not pit or scar the surface of the metal being cleaned. To evaluate the grits in respect to pitting, polished brass and aluminum panels were blasted for periods of 5 min. with each of the various grits. The 5-min. exposure of the metal panels to the action of the grits is longer than customary in normal cleaning practice, but was used to permit development of significant patterns on the surface of the 2¼-in. test squares. The surface finishes obtained by the use of the various grits are illustrated in an accompanying figure. Pitting observed during preliminary tests was shown to be caused by inclusions of metal particles not removed in the preparation of the grits. Preparation was modified sub-

sequently to remove steel inclusions by magnetic separation before use. When rice hulls were used in conjunction with the grits, a satinlike finish resulted.

The various factors involved in blast cleaning permit modification of the method to meet immediate circumstances. Combinations of grits and hulls may vary over a wide range, for example, from proportions of 90 parts grits and 10 parts rice hulls to 35 parts grits and 65 parts hulls. Air pressure used can be varied to change the character of the surface finish. Effectiveness of cleaning is altered by the angle of impingement, according to Stoker, who used silica sand in blasting studies on black iron.

While the durability or life of grits from the shells of nuts and fruit pits is somewhat less than for clean, dust-free corncob grits, the cleaning rate is faster and efficiency is greater. Thus, in the case of shell grits alone, the efficiency might offset their shorter life. The relative efficiency of the grits in respect to corncob grits is less pronounced when the grits are used with rice hulls. Grits from cherry pit shells, while very effective in cleaning by the blasting method, are quite friable and disintegrate readily to a fine powder.

Results of Tests on Soft Grits

Penetration of paint films, and change in particle size, including dust formed during blast cleaning by soft grits.

Type of Grits	Penetration Time, Sec.		Dust Removed in 1 Hr., %	Total Material Passing No. 30 Sieve	
	Grits Only	Grits Plus Rice Hulls		Before Blasting, %	After 1 Hr. Blasting[1], %
Hardshell Almond Shell	9	7	2.9	3.2	26.7
Softshell Almond Shell	9	7½	2.1	3.9	51.2
Apricot Pit Shell	11½	7½	6.2	4.2	31.1
Cherry Pit Shell	7	3	39.7	4.1	83.9
Coconut Shell	4	4½	3.7	5.9	34.7
Corncob, Commercial					
As Received	—	—	4.4	3.0	23.8
Screened	—	—	5.6	1.0	15.8
Air-separated	22	20	1.8	1.1	6.2
	22-35	10	1.9	3.1	14.3
Filbert Shell	6½	5½	1.3	2.4	28.7
Peach Pit Shell	5½	5½	1.7	4.8	18.6
Pecan Shell	5½	7	1.2	3.6	12.1
Black Walnut Shell	4	4	1.4	3.8	22.0
English Walnut Shell	5	5	2.9	0.2	9.4

[1] *Dust removed in 1 hr. has been included in these values.*

Methods of Cleaning

One equipment manufacturer recently introduced a moderately-priced, pressure-type blasting unit designed specifically for use with soft grits from agricultural residues. Acceptance of this equipment by large industries, such as steel mills and manufacturers and users of electrical equipment, for degreasing and cleaning large electric motors and generators, was almost immediate. Grits, No. 20/60, from corncobs or hardwood sawdust are preferred materials for degreasing because of their absorbency and efficiency in cleaning electrical equipment without deleterious effects on the insulation and windings. The former method of degreasing and cleaning electrical equipment necessitates the use of toxic and inflammable solvents. In some instances, this has resulted in fatalities even among employees not associated with the actual cleaning operations. A physician reports that only those individuals in the immediate vicinity (10-ft. radius) of the blasting need wear protective devices. This, of course, is for cleaning done in the open without hoods.

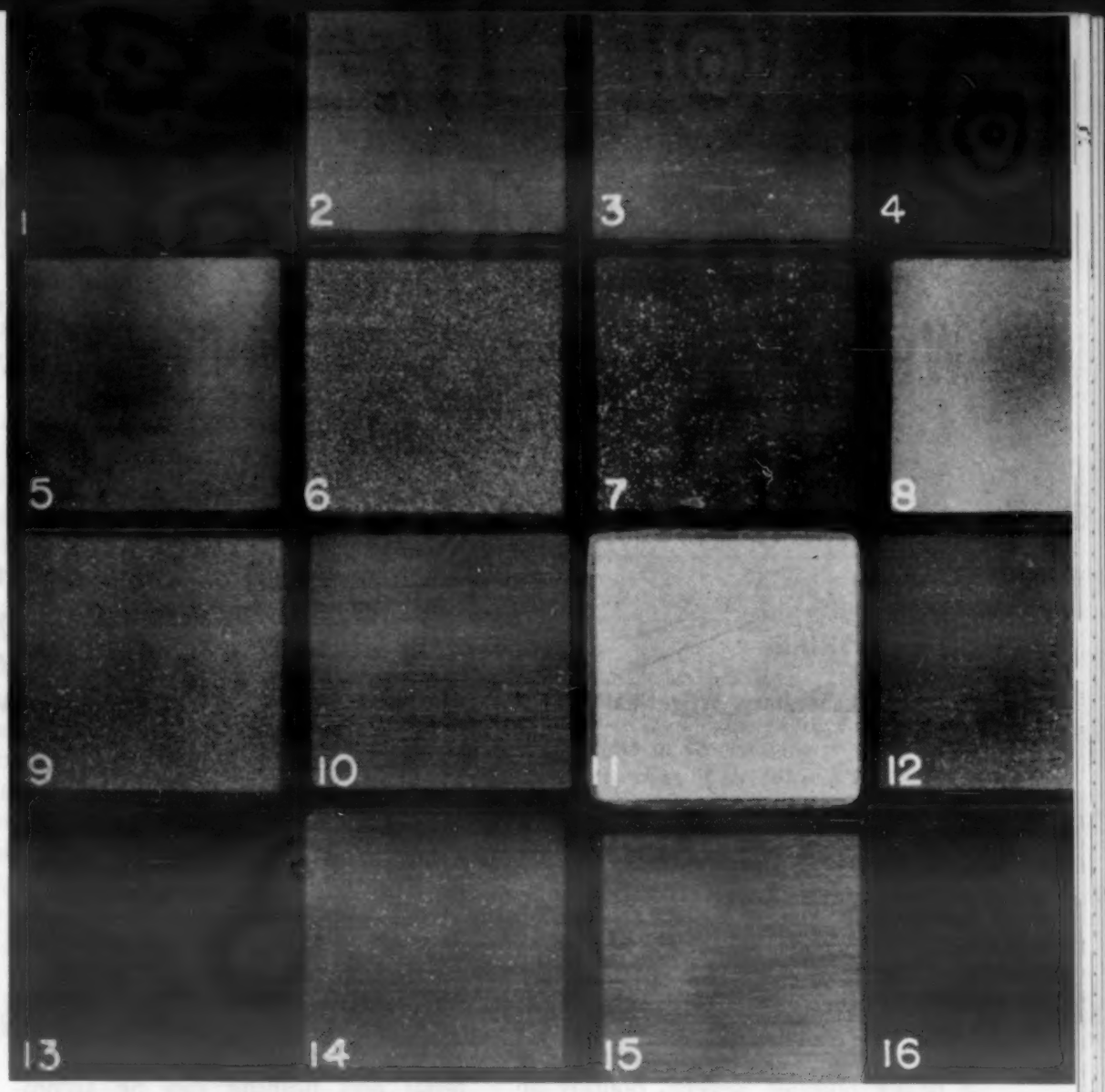
The soft-grit method of cleaning not only eliminates the hazards surrounding the older methods, but is considerably more economical in respect to time and materials. The time required to degrease and recondition electrical equipment by this new method is only a fourth to a third of that required by older methods. The soft-grit method is a dry

Conventional equipment is reported suitable for soft grit blast cleaning of metals. (Courtesy The American Wheelabrator & Equipment Corp.)

operation, and long periods of drying are not required before the equipment can be replaced in service. Surfaces are ready immediately for painting or varnishing. The low cost of the soft grits allows for their disposal after one use. This last factor should be a major consideration in food processing industries where freedom from contamination and toxic materials is of prime importance.

The effectiveness of soft grits is the same regardless of the size of the object to be cleaned. For objects too large to be placed in conventional booths, portable blast units can be used at the site of the equipment. Since the low cost of grits allows for their disposal after being used once, no elaborate shielding is required to prevent loss of the used grits.

Producers of soft grits are cautioned to use extreme care in preparing grits. Physical character of the grits and freedom from extraneous materials are highly important. Tramp metal, of course, must be removed before grinding is done, and the finished grits should be passed over a magnetic separator just prior to packaging to remove particles of steel that might originate from grinding disks, rolls or hammers.



Surface finishes obtained by blasting various soft grits against a panel of polished aluminum. All grits were No. 12/30. Nos. 1, 4, 13, 16: Control panels. 2. Hard almond shell. 3. Apricot pit shell. 5. English walnut shell. 6. Red corncobs. 7. Soft almond shell. 8. Pecan shell. 9. White corncobs. 10. Filbert shell. 11. Red corncob-rice hull mixture, 9:5. 12. Coconut shell. 14. Black walnut shell. 15. Peach pit shell.

Applications

Availability of inexpensive equipment designed to handle soft grits should extend the adoption of this method of cleaning to the metal working industries and to automotive service stations, machine shops and the smaller maintenance and repair shops. For general cleaning other than of electrical equipment, the grits from nut and fruit pit shells, with or without rice hulls, are satisfactory.

Welding scale is effectively removed from fabricated steel plate by grit-rice hull mixtures, and the cleaned surface of the metal is considered satisfactory for subsequent painting. Rice hulls appeared to be an essential component of the blasting mixture for this purpose because grits alone fail to remove the colored oxide film under the welding scale. Because soft grits do not cause pitting, this method appears to be superior to the practice of using steel grits. Pitted surfaces resulting from use of steel grits cause early failure of subsequently applied paint films.

Polishing metal surfaces by means of soft-grit blasting at present is not recommended when gloss or high luster is desired. Blast cleaning removes minute films of metal or metal oxides, thereby exposing fresh metal surfaces. Hot-dip tinned and other plated parts acquire a satin finish even under extremely mild blasting conditions. Modification of grits and techniques in respect to angle of impingement, quantity and size of grits in air stream and other factors may result in acceptable polishing and burnishing procedures.

Blast cleaning of metal surfaces prior to plating or galvanizing is another suggested application for soft grits. Cleaning by soft-grit blasting is particularly effective where the surfaces of the metal under its coat of dirt, scale, carbon, etc., should remain unchanged or otherwise unimpaired.

Equipment or machines covered with deposits of grease, oil or dirt during normal operation, as well as articles coated with metal preservatives or rust preventives for storage or shipment, are readily cleaned for continued operation, assembly, or painting. The greases, gums, waxes, asphalts or varnishes present in preservatives cause no difficulty of removal by the soft-grit method. For such application, discarding the grits after one use may be advisable to maintain the method at peak efficiency and avoid contaminants which might ultimately result in blemishes on the surfaces. This procedure still represents considerable economy compared to cleaning with solvents.

Removal of greases, oils and abrasives from plate glass by soft grits, particularly those of corncobs, has been accomplished without damage to the polished surface. However, rice hulls in the soft grits will cause a frosted or etched surface similar to that obtained with fine emory dust. This was as anticipated because of the abrasive character of the rice hulls.

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Strong Ductile Alloy Steel Permits Weight Saving in Structural Parts

by D. A. SHINN,

Materials Laboratory, Wright-Patterson Air Force Base

The impact properties at high strength levels of Hy-Tuf, a relatively new nickel-chromium-molybdenum steel, compare favorably with those of SAE 4340 and suggest its use for such critical applications as aircraft structures.

● THE ELIMINATION OF excess weight in aircraft is of such great importance that it cannot be over emphasized. An idea of weight penalties can be obtained from the fact that for a heavy bomber, several pounds of gasoline are required to propel each additional pound of airplane to and from its destination. Thus, the saving of a pound of dead weight will, in effect, save several pounds.

In trying to save weight the designer has three structural metals with which to work—aluminum and magnesium alloys and steel. In the case of steel, SAE 4340 has been most prominent in aircraft structural applications in the range of strength between 200,000 and 240,000 psi. In the past couple of years a new patented steel, designated Hy-Tuf and produced by Crucible Steel Co., has been introduced. This new steel has high ductility and impact values at high strength levels (220,000 to 240,000 psi.) and should aid materially in weight reductions. This article presents information on the hardness, impact resistance and notched and unnotched tensile and fatigue strengths of this steel at room and subzero temperatures. Some data of this type have been published but, so far as is known, this is the first time that all of the data presented have been determined on one lot for each material by one investigator. The tests were made by the Ohio State University Research Foundation on contract to the Air Materiel Command.

While steel is the subject of this paper, a brief comparison should be made at this time between it and the two nonferrous materials. The major aluminum and magnesium alloys are delivered to the aircraft company at a given strength for each specific material and nothing can be accomplished by the designer to increase that strength. The only alternative is the continuing attempts to improve the efficiency of the design and hope for higher strength materials in the future. However, in the case of steels the designer has a fairly wide strength range at his disposal and may use parts in which the material is heat treated to well over 200,000 psi., provided he can meet the limitations involved. As a result of this versatility, steel is being exploited at the high strength levels for all the benefits that can be obtained. There are, of course, difficulties involved and, as usual, they have not remained dormant. Steels used in structural parts stressed to high loads are inclined to display a tendency toward failures at points where combined stresses are present, and the need for ductility is manifest in such cases.

One of the most important applications of steels of the types exemplified by Hy-Tuf and SAE 4340 is in aircraft alighting gear. These structures are dead weight once the airplane is in the air and must therefore be as light as possible but still support high loads applied at very rapid rates under complex stress conditions when the airplane is landing. Since increased rates of loading are somewhat similar in effect on mechanical properties as decreased temperatures, the effect of the low temperatures as given in the tables and figures accompanying this article should furnish an indication of the relative effect of high rates of loading on Hy-Tuf and SAE 4340 parts.

Description of Steels

The two steels that were tested had the following chemical analyses:

	C	Mn	Si	P	S	Ni	Cr	Mo
Hy-Tuf	0.26	1.26	1.37	0.016	0.017	1.91	0.09	0.43
SAE 4340	0.46	0.70	0.29	0.018	0.031	1.78	0.95	0.23

The Hy-Tuf was austenitized at 1575 F, oil quenched and tempered at 550 F. The SAE 4340 was heated 1 hr. at 1550 F, oil quenched and tempered ½ hr. at 800 F. Both materials were furnished and treated as ¾-in. rounds, the Hy-Tuf being received in the annealed and the SAE 4340 in the hot rolled condition.

It should be noted that the Hy-Tuf was tempered at a temperature 250 F below that used for the SAE 4340 (550 and 800 F) which may be enough to have resulted in more internal stresses in the Hy-Tuf. The lower yield strength and proportional

limit of the Hy-Tuf may be indicative of this condition, the yield-ultimate ratio being 0.85 for the Hy-Tuf and 0.93 for SAE 4340. However, if tempering temperatures of 700 and 750 F are used for the Hy-Tuf, yield-ultimate ratios of 0.87 and 0.90 are obtained (Crucible data sheet DS185) since the yield strength remains at a nearly constant value of 190,000 to 195,000 psi. while the ultimate strength decreases from 231,500 to 210,000 psi. It may, therefore, be desirable to use these higher tempering temperatures (since the yield is nearly as high as obtainable) if internal stresses are thought to be critical in a particular application.

In any case, it would seem desirable that Hy-Tuf be investigated at the high strength levels for the effect of any residual stresses which may be present, since the high impact values indicate possibilities for use of the steel heat treated to these strengths. A further factor which must be considered is that Air Force-Navy Aeronautical Specification AN-H-201 lists a minimum tempering temperature of 700 F, unless specific approval is obtained for lower temperatures, for all steels except SAE 4340 and 6150, for which it is 650 F.

All tests were made at room temperature and liquid nitrogen temperature (−320 F); hardness and impact tests were also made at liquid hydrogen temperature (−423 F). The specimens were immersed in the appropriate liquid (acetone and dry ice, liquid nitrogen, liquid hydrogen, etc.) at the time each test was made. Tension tests were made in an Olsen universal testing machine using SR-4 electric strain gages. Fatigue tests were made in Krouse cantilever plate testing machines using a round specimen. Impact tests were performed in a 220-ft.-lb. capacity testing machine having an impact speed of 18.1 ft. per sec. and hardness tests in a Vickers Hardness testing machine using a pyramidal diamond. The tension and fatigue specimens both were 0.300 in. in dia. for unnotched specimens and also at the root of notched specimens. The 60-deg. notch in both cases was 0.025 in. deep with a 0.010-in. radius at the bottom. The standard keyhole notch was used for Charpy impact specimens.

Comparison of Properties

The results of tension tests are shown in the accompanying table. It will be noted that the room temperature unnotched values are practically identical, making the comparison of other values between the two materials as valid as possible if

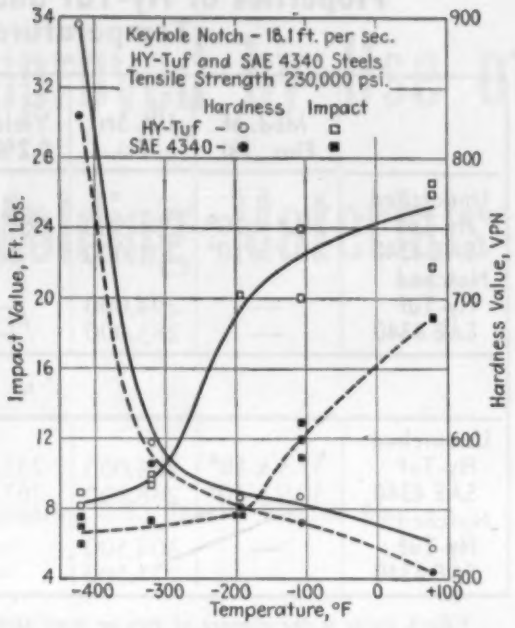
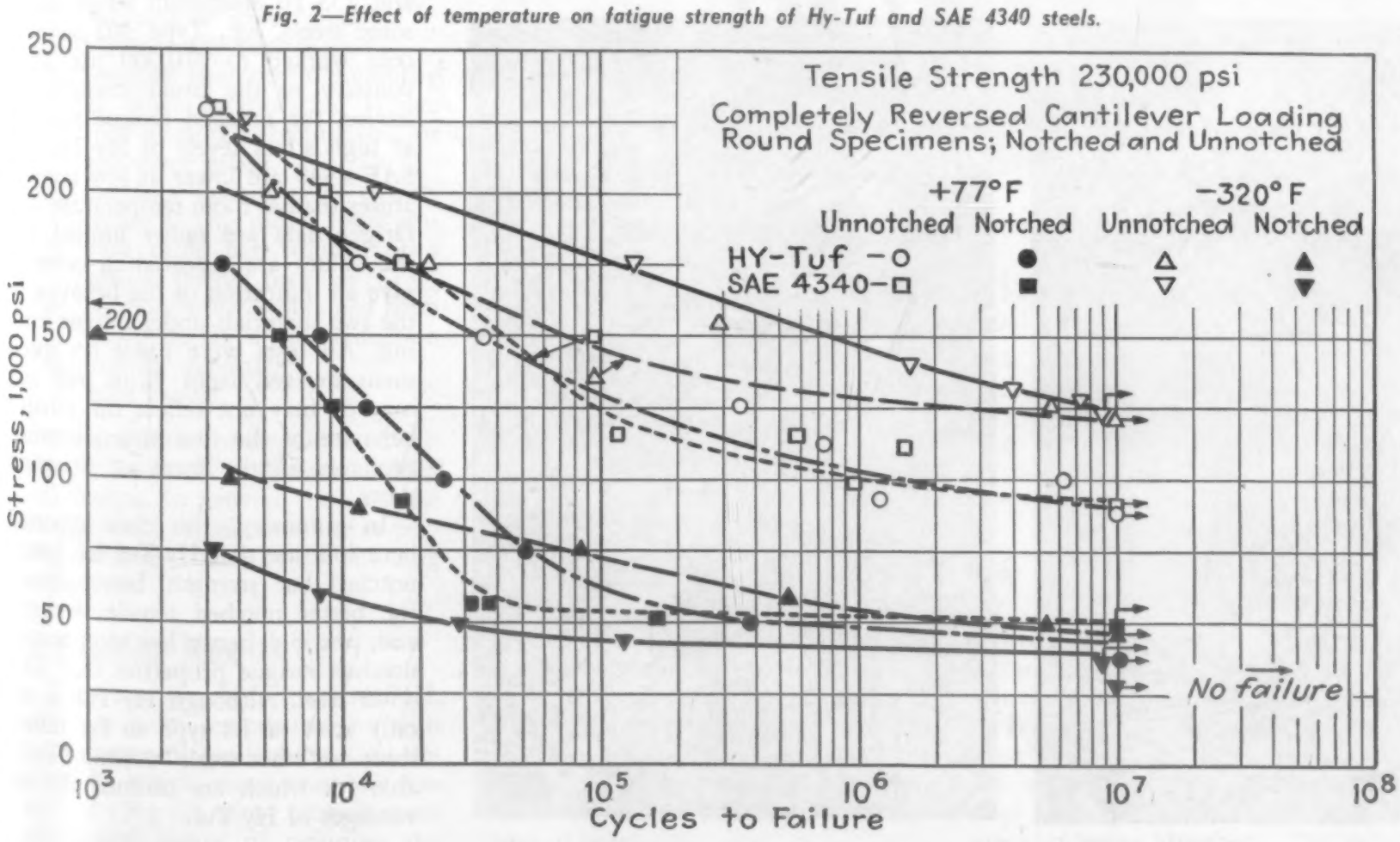


Fig. 1—Effect of temperature on hardness and impact values of Hy-Tuf and SAE 4340 steels.

based on such original values. The true ultimate strengths were somewhat different, that for Hy-Tuf being a little higher than SAE 4340.

The test results showed that the modulus of elasticity of Hy-Tuf increases somewhat more with temperature decrease than SAE 4340, but the differences may not be significant. Other increases in tensile values of unnotched specimens were more or less similar. However, ductility in the SAE 4340 is more severely

Fig. 2—Effect of temperature on fatigue strength of Hy-Tuf and SAE 4340 steels.



Properties of Hy-Tuf and SAE 4340 Steels at Room Temperature and —320 F[1]

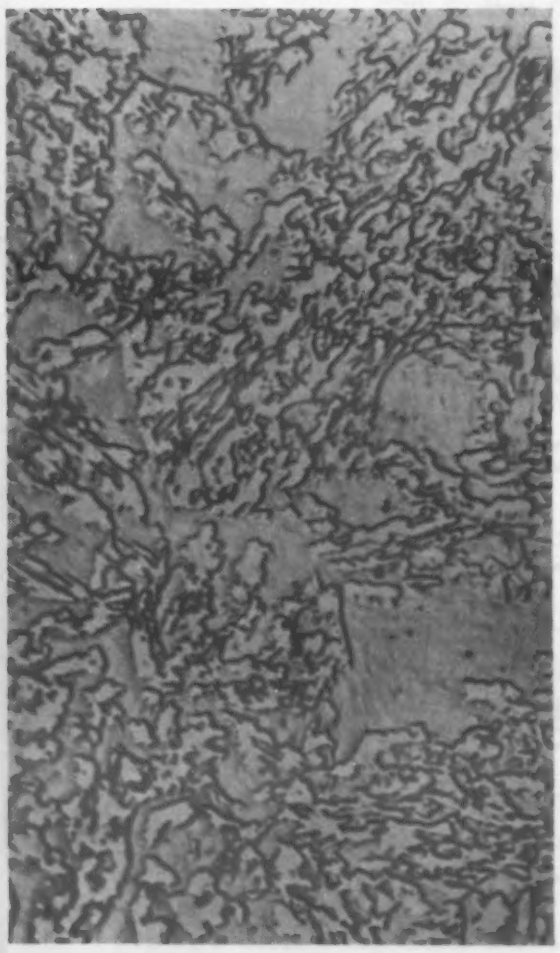
	Mod. of Elas., Psi.	Ult. Str., Psi.	Yield Str., 0.2%, Psi.	True Ult.[2] Str., Psi.	Red. in Area, %	Elong. in 1.2 In., %	Elong. in ¼ In., %
Unnotched							
Hy-Tuf	29.8×10^6	231,500	196,200	346,000	44	11.6	—
SAE 4340	30.7×10^6	231,000	214,000	315,000	46	11.7	—
Notched							
Hy-Tuf	—	294,000	—	312,000	7.4	2.4	4.9
SAE 4340	—	283,000	—	294,000	3.6[3]	0.8	3.9
at —320 F							
Unnotched							
Hy-Tuf	31.3×10^6	283,000	233,000	383,500	33	12.0	—
SAE 4340	30.9×10^6	288,000	267,000	323,000	11	4.1	—
Notched							
Hy-Tuf	—	304,500	—	309,500	2.4	0.4	1.8
SAE 4340	—	271,500	—	279,500	2.7[3]	0.4	1.3

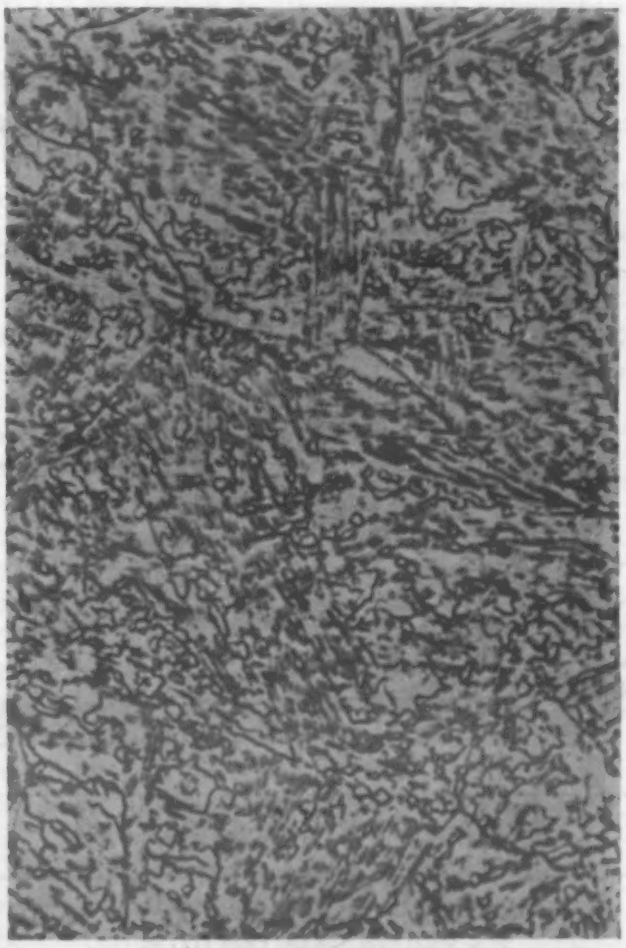
[1] *Each value is the average of two or more tests.*
[2] *Load at fracture divided by area at fracture.*
[3] *At root of notch.*

affected than for Hy-Tuf. For notched specimens the Hy-Tuf increases in strength and the SAE 4340 decreases in strength with temperature decrease. However, while the Hy-Tuf shows higher notched ductility at room temperature, at —320 F the two materials are comparable.

The change in hardness for the two materials was found to be similar, the outstanding feature being the sharp increase for both between —320 and —423 F, this increase being more than three times as much as the increase between +77 and —320 F. The results are shown in Fig. 1. It will be interesting to learn the effect of this additional decrease in temperature on mechanical properties. These tests are being initiated.

Micrographs showing metallurgical structure of Hy-Tuf. Left, acicular ferrite formed in 20 min. at 800 F. Right, Bainitic transformation product formed in 20 min. at 700 F. (Courtesy Crucible Steel Co. of America)





The results of Charpy keyhole impact tests are also shown in Fig. 1 and indicate no spectacular change in values between —320 and —423 F as exhibited by the hardness values. The figure shows the rather marked superiority of Hy-Tuf over SAE 4340 in the impact values, especially at temperatures down to —320 F.

Fig. 2 shows the effect of temperature and notches on the fatigue strength of the two materials. There seems to be no appreciable advantage for one material over the other at either room or low temperature in the unnotched condition. The only comment worthy of note for this condition is that the low temperature tends to straighten out the knee of the curve slightly for both materials. This effect is much more pronounced for the notched specimens.

Notching alone gives a slight advantage to the SAE 4340 material at large numbers of cycles and to Hy-Tuf at low numbers of cycles. However, at low temperature the advantage is in favor of Hy-Tuf at all numbers of cycles. An important point relative to both materials is the rather sharp decrease from room to low temperatures in the number of cycles to failure at the higher stresses. For example, at 100,000 psi. Hy-Tuf fails in 3700 cycles at —320 F and goes seven times as long, or to 25,000 cycles, at room temperature. This condition does not arise in nonferrous materials like 24S-T3 and 75S-T6 aluminum alloys nor in some steels, *e.g.*, Type 302 stainless cold worked to 210,000 psi. Thus, contrary to the usual strength behavior, the notched fatigue strength at high stress levels of Hy-Tuf and SAE 4340 are lower at low temperatures than at room temperature. The fatigue data are rather limited, but the values are reported in order to give an indication of the behavior of the two materials under fatigue loading. All tests were made on specimens derived from ¾-in. rod and may or may not reflect the relative behavior of the two materials when produced in the form of structural parts.

In summary, the data reported here indicate that Hy-Tuf has better notched bar strength, better ductility, better notched tensile strength, and, possibly, better low temperature notched fatigue properties than SAE 4340 steel. Although Hy-Tuf is the only steel of its type so far tested, there are other steels becoming available for which are claimed the advantages of Hy-Tuf.

Coil Designs Improved by Use of Cold and Hot Molding Materials

by B. W. ERIKSON, Control Engineering Div., General Electric Co.

Many different insulating compounds now available can be molded or cast around electrical devices, such as small magnet coils, to produce a higher quality product.

• IN RECENT YEARS much thought has been given to molding or potting materials which can be molded or cast around the entire exterior of small magnet coils. Such insulating compounds in many cases can replace the older conventional materials, such as papers, tapes, cloth, fiber, mica, pre-fabricated spools, or separately molded phenolic spools of conventional construction.

The advantages of completely encasing a coil in a molding compound are:

1. Dimensionally very uniform.
2. Neatness of appearance.
3. Mechanically very rugged.
4. Strongly resistant to humidity or other deteriorating factors such as fungi, termites, oil, or salt water splash.
5. Excellent heat transfer characteristics. This means more ampere turns per volume, or a smaller overall package.
6. As more work is obtained from less material, a cost reduction may be expected.
7. Sales appeal.

Many different materials are available for use in the making of molded coil designs. In general, they may be classified as (1) cold molding or potting materials, and (2) hot molding materials.

Cold Molding Materials

These are materials that are fluid, either at room temperature or with some degree of pre-heating. Coil designs in which these materials are utilized (Fig. 1) often provide some mechanical means of retaining the compound in the coil structure and around it. This may be done by so arranging the insulation materials, that the compound does not drain away, or by placing the coil in a temporary mold. If the compound is poured in an open type mold, setting up of such compounds may be accomplished either by heat or with the addition of chemical accelerators. This, of course, also applies to coil designs where the compound is retained by the mechanical construction of the coil, as shown in Fig. 2. Most molding compounds available and described in this article will set in a fairly short period of time if mixed with the proper accelerators with or without additional application of heat.

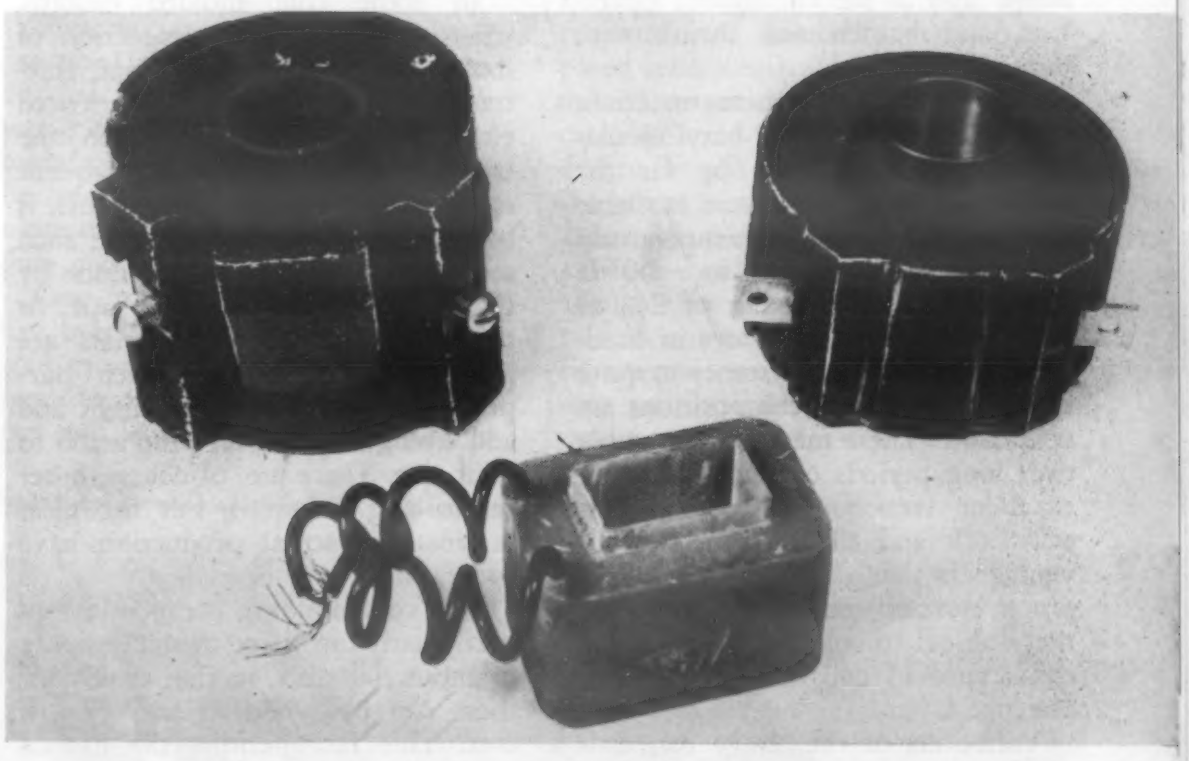


Fig. 1—Some examples of coils encased with cold molding compound.

Materials commonly used for cold molding processes are:

1. Asphalts
2. Waxes
3. Styrene casting compounds
4. Castor oil-butyl methacrylate compounds
5. Inorganic compounds (concrete, expandotite)
6. Polyvinyls
7. Phenolic compounds

Each one of these materials has advantages and disadvantages. For instance, the asphalts and waxes soften at fairly low temperatures, approximately 167 to 212 F. The inorganics are usually hard, even brittle, and tend to shatter under impact. They are also water absorbent. The poly-

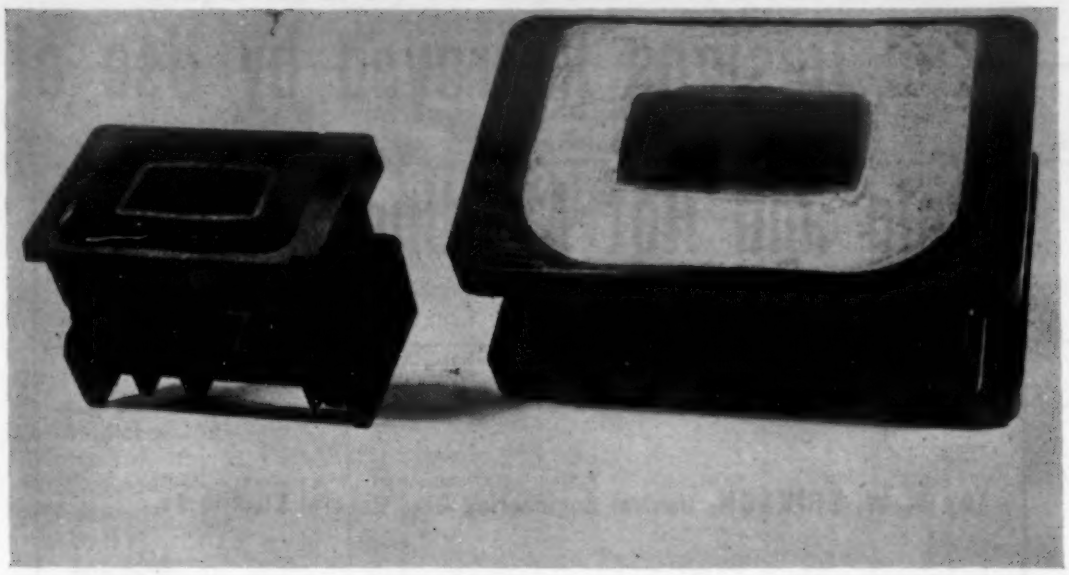


Fig. 2—In coils of the design shown here, molding compound is retained by the mechanical construction of the coil.

vinyl type of materials do not rate above 194 F for continuous operation, and harden and shrink with temperature aging.

In comparison to these materials, the styrene or castor oil-butyl methacrylate compounds are by far the best. Compositions are here available for continuous service at temperatures up to 300 and down to −60 F. Shrinkage is in the order of 2% or less by volume. All degrees of hardness from rubber consistency to quite hard, almost brittle compositions are obtainable. These materials are stable over long periods of time, and offer excellent resistance to moisture, acids, oils and alkalies. Another advantage is that they do not tend to sag at elevated temperatures, nor are they subject to cold flow. For typical appearance of coils before molding, see Fig. 4.

Variations of the above materials can be produced with the addition of inorganic fillers, such as silica flour (sand), talc, or others. Such additions are used to produce less shrinkage, to improve heat transfer, change viscosity, increase mechanical strength, or to reduce cost. Actual percentage of filler most desirable for a particular application must be determined by test. No method is available for pre-calculating the effect of such changes.

The principal advantage of the cold molding materials is that they require no appreciable pressure for the molding or potting operation. This is often a determining factor in a new product, as many coil designs are of such a nature that any sizable pressure in the molding operation would distort or damage the winding structure. This applies in particular to paper layer wound designs.

In some cold molded designs, where the available cross-section of molding material is not great, fracture difficulties may be experienced either during the time when the compound is setting or in subsequent operation. To protect against this, it becomes desirable to reinforce such sections, and this is readily done by the addition of glass fiber, tape, or glass matting. These materials are particularly suitable for such purposes as they are thin and light and add strength out of all proportion to their size. There are, of course, other reinforcing materials, but the glass products in actual production have proven much the best.

The cold molding compounds are particularly attractive to the designer of industrial coils, in that molds for these can be produced at very low cost. This fact permits the use of these materials for relatively low production items where mold costs normally associated with plastic parts could not be tolerated.

Inexpensive molds can be made in several ways. The most practical is to obtain a pattern from wood, plastics or metal, and then to cast this pattern in Woodsmetal, Kirksite (Al-Zn), or a polyvinyl compound. These molds can be made in sections or in one piece by supplying proper knockout pins. Many molds can, of course, be made from the same pattern.

Hot Molding Materials

Hot molded plastics of the wood flour or cotton flock type have been used as coil spools for many years. However, as molding pressures are in the order of 2000 psi., these materials are not suitable for molding a plastic shell around the exterior of a coil winding similar to that produced with the potting compounds described previously. Several early attempts to hot mold small magnet coil designs with conventional phenolic plastics invariably produced severe distortion of the coil wires, and in most cases actual destruction. Molding materials of suitable characteristics and with much lower molding pressures were needed. In recent years, materials which meet most of these requirements have become available. Some of these are:

1. Polyethene
2. Butyl rubber, and other nitrile and phenolic synthetic rubbers
3. Tung oil jells

Even these materials constitute only a partial answer to the problem of hot molding or completely encasing small magnet coils in a protective shell. The polyethenes, which are injection molded in the liquid state,

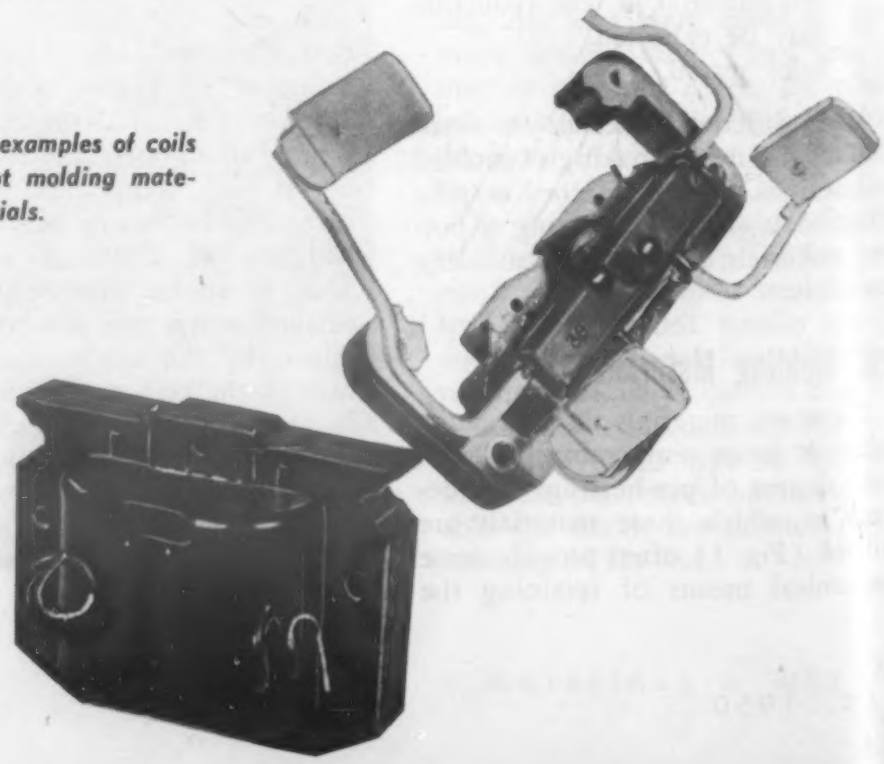


Fig. 3—Some examples of coils made with hot molding materials.

have relatively poor temperature resistance. These materials should not be used above 212 F, and above 167 F they are subject to some cold flow under stress. The polyethene materials are the only well-known ones available to the coil designer for complete hot molding of small paper layer wound coils. The molding pressure is practically zero, and no mechanical distortion takes place. Practically all other similar materials which are suitable in this temperature range have much higher molding pressures and, therefore, cannot be used.

Where molding pressures are not objectionable, such as in solid copper bar coil designs, several other materials come into the picture. The more popular of these are the rubber formulations mentioned previously. Compounds of this type have been used for current transformer designs, and for other heavy wire series rated coils where the molding pressures do no damage. For examples of hot-molded coils, see Fig. 3.

Cost Factors

The molding materials described in this article are relatively inexpensive on a pound or gallon basis. However, they require a manufacturing process different from normal. This usually also includes some special fixtures or tools. These facts indicate that the most advantageous applications of these materials may be found in large production items where above normal quality is necessary.

Once a process has been established in a working area, it will be found that certain cost reductions result. These are usually due to the omission of conventional finishing materials that are no longer necessary, and, in many cases, reductions in actual labor content per unit.

It should, however, be borne in mind that after a molding material and its process of application has been selected, a whole new concept of coil manufacturing must be learned. This requires close cooperation between engineering and factory personnel.

Service Applications

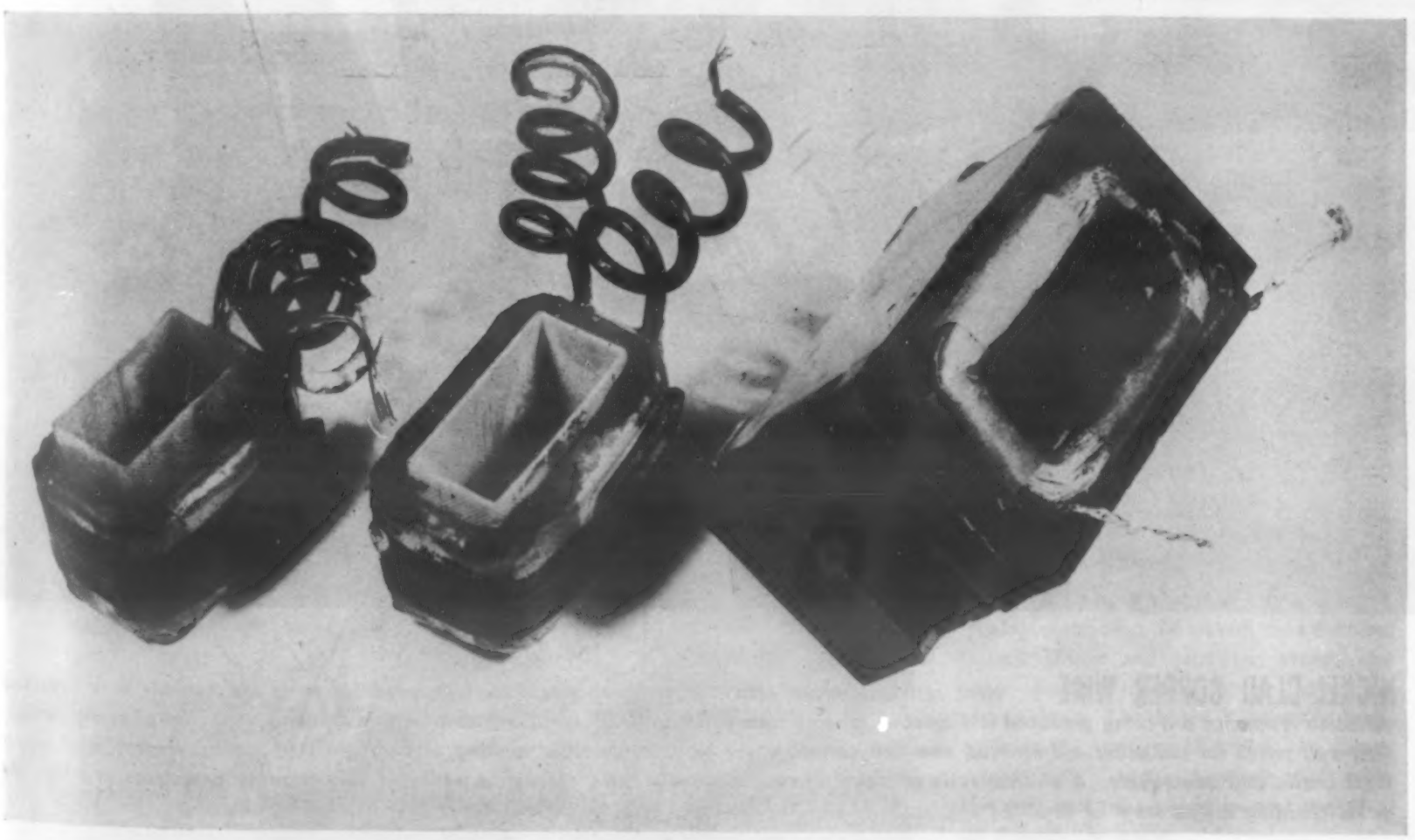
Several coil designs of the types described above are in current production. Some of these known to the writer have been out for two years or more and have shown themselves to be very high quality designs with more than usual endurance on severe duty cycles.

One solenoid application which has been successfully met with the cold molded design shown in Fig. 1 requires operation at the rate of 600 per min. Another design of a similar type shown in Fig. 2 is rated on the basis of a minimum life expectancy of 10,000,000 operations. This is far above the performance of conventional paper layer wound or random wound small magnet coil designs.

The above field experience parallels earlier model testing on a laboratory basis. These tests consisted, in the case of the coils shown in Fig. 2, of subjecting sizable groups of these coils to a temperature aging-humidity cycle followed by actual operation. The test cycle used for this particular design consisted of three weeks aging in an oven at 300 F, followed by 500,000 operations, one week at 100% relative humidity, 10,000 operations at rated voltage, and a repeat of the cycle. This laboratory test, which was taken in conjunction with additional operating tests in which 10,000,000 operations were obtained on large groups of coils without temperature and humidity, was compared with similar data obtained for more conventional designs. In every case, the cold molded or potted coil design would outlast and out-wear the others in a ratio of approximately 2:1.

Much additional test data are available for other designs, but these two, as shown in Figs. 1 and 2, are representative of the results which may be obtained by designs of this nature.

Fig. 4—Typical appearance of coils before potting or molding.



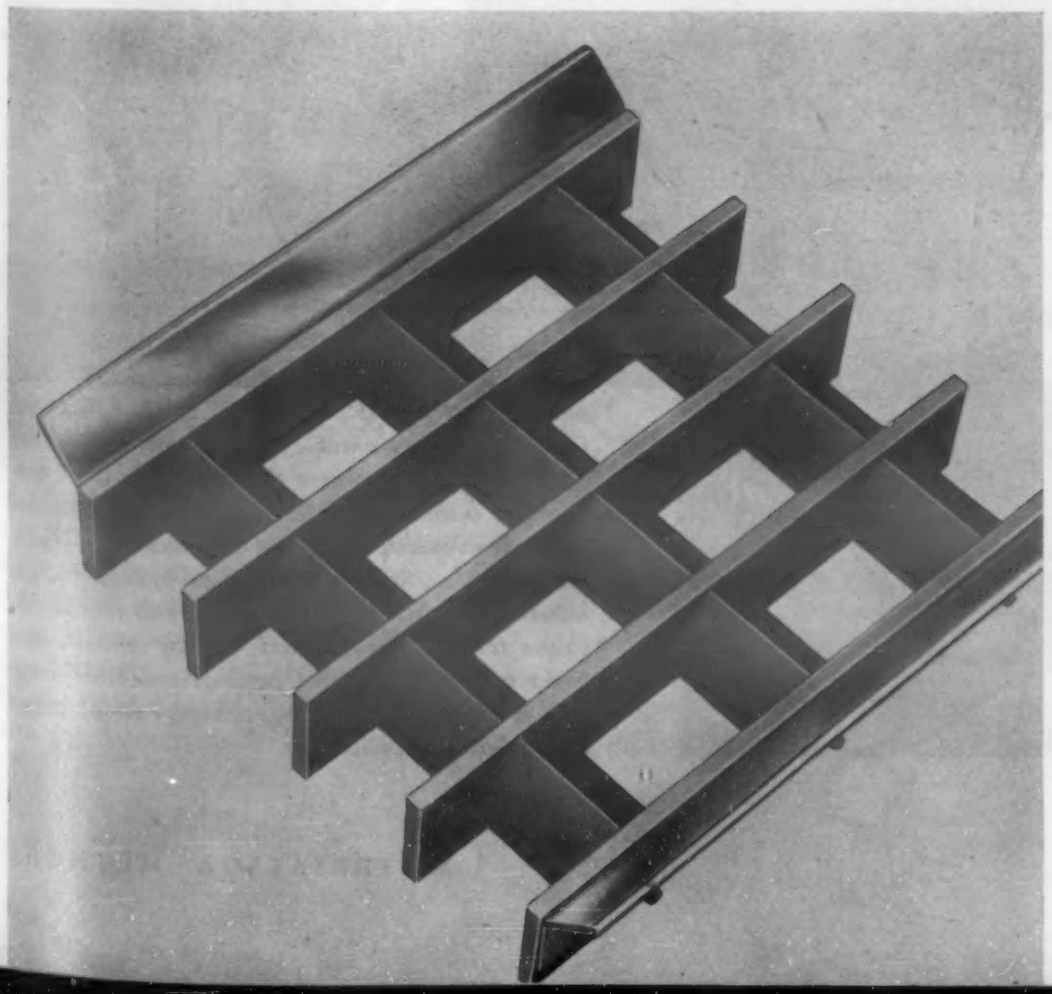
Materials at Work

Here is materials engineering in action . . .
New materials in their intended uses . . .
Older, basic materials in new applications . . .

NICKEL-CLAD COPPER WIRE *Heat resistant, nickel-clad copper wires which combine good electrical conductivity with heat and corrosion resistance are being produced in diameters ranging from 0.010 to 0.005 in. by Sylvania Electric Products, Inc. The wires are particularly well-suited for stranding and for lead wire applications where high temperature working of hard glass frequently renders solid copper wires brittle and unworkable. A uniform ratio of nickel to copper is maintained through a series of cold drawing operations in which the nickel-cladding ranges from 27 to 29%.*

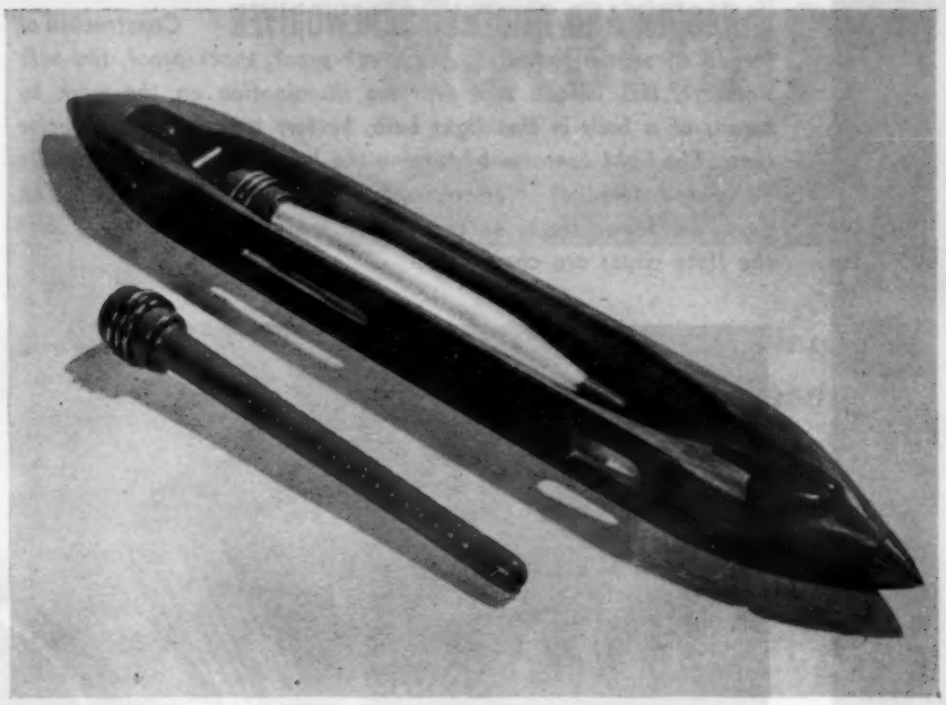
CELLULOSE ACETATE HOUSING *Injection molded in two nesting halves, the housing of this electric deodorizer is made from a flame-resistant, self-extinguishing type of cellulose acetate. The motor, circulating fan, and scent block assembly of the unit is mounted in a metal wall bracket by means of four bronze bushings in the lower half of the housing. The complete unit deodorizes through a principle of dry vaporization as compared to the drip method customarily used. (Photo courtesy Hercules Powder Co.)*

VANADIUM AND AMBERYL SCREWDRIVER *Constructed of forged chromium vanadium and break-proof, shock-proof, fire-safe Amberyl, this unique tool provides illumination on the work by means of a built-in flashlight bulb, battery and directional lucite lens. The light operates by turning the knurled knob in the handle dome and does not interfere with manipulation of the tool. The deep, molded-in flutes on the handle provide a vacuum grip, and the flute edges are chamfered.*

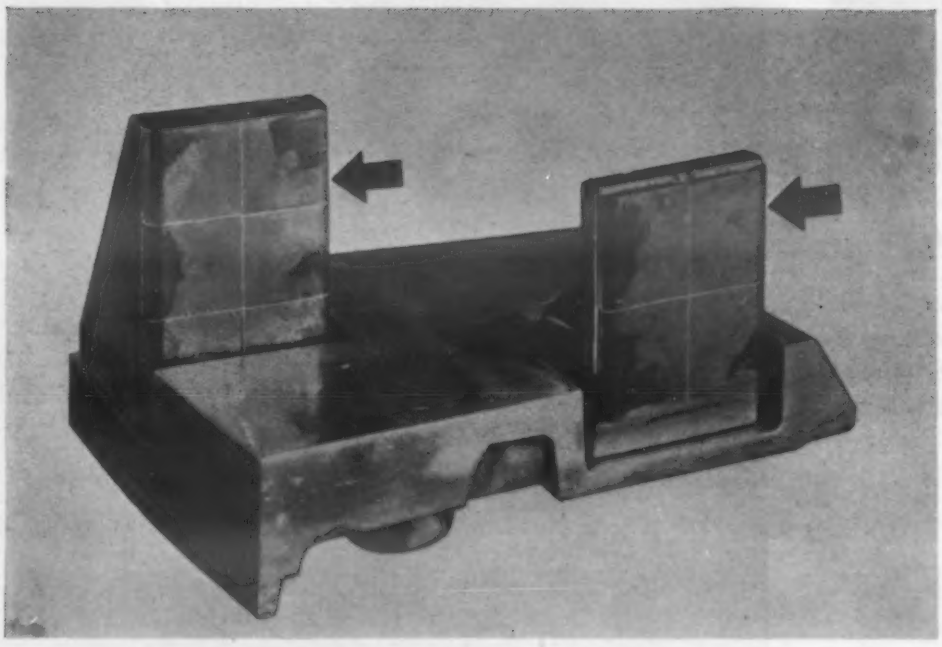


ALNICO GRATE *Designed to be placed in the hopper and readily removable for cleaning, this permanent magnet separator is manufactured by the Bauer Bros. Co. Magnetized Alnico bars and iron spacers deflect material and cause the streams of flowing material to be sieved, thus enabling ferrous pieces and particles, stones and other foreign matter to be effectively screened out. The device is primarily applicable to the handling of coffee, tea, spices, grains, nuts, beans, chemicals and other flowable materials of sufficient fineness to go through the grate.*

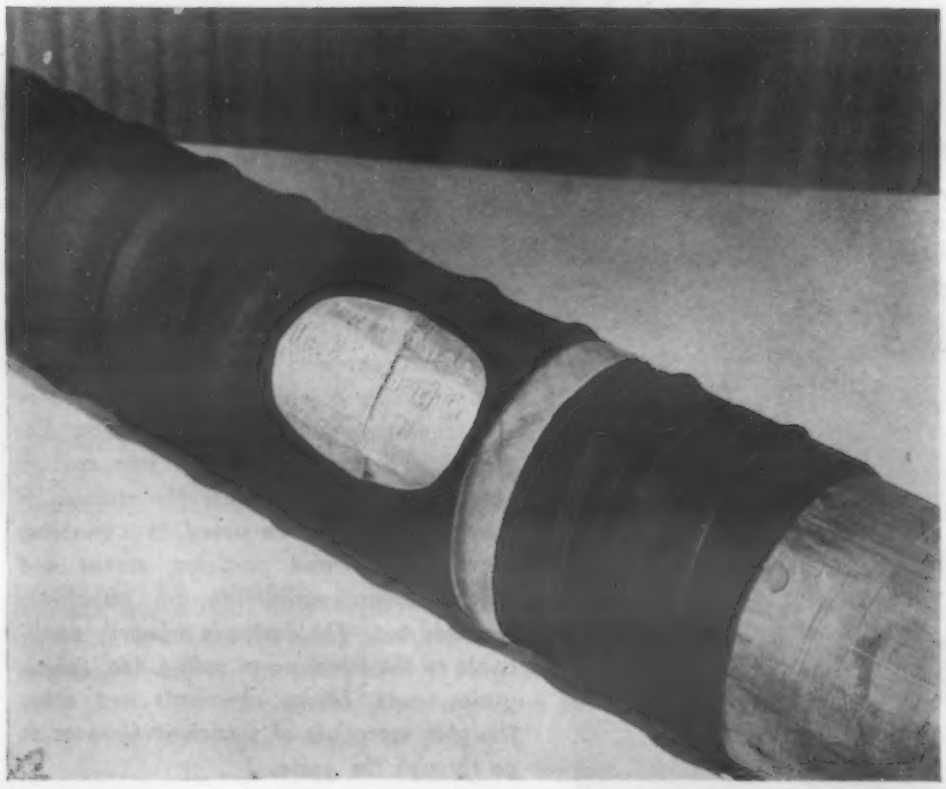
Materials at Work



PLASTIC LOOM BOBBINS *Replacing maple bobbins that required frequent repolishing, these acetate and propionate quills or loom bobbins are injection molded. After molding, metal rings are pressed on the outside of the butt of the bobbin and a metal insert is placed in the bore of the butt for proper alignment in the shuttle of the loom. Although the plastic quills cost more than the former wooden types, this price differential is more than offset by the longer life and lower upkeep costs of the plastic quills, since they wear indefinitely, do not warp, chip or shrink in handling, and retain a desirable surface.*

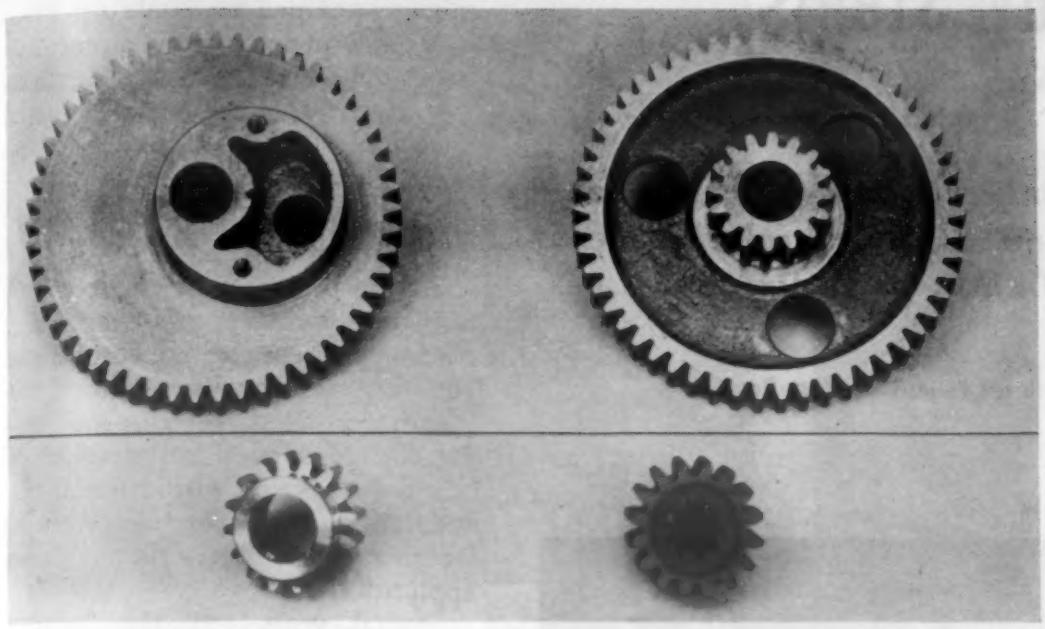


CARBIDE-FACED PULVERIZER PEGS *Replacing cast pegs in a Riley coal pulverizer, these forged steel pegs faced with carbide have shown no appreciable wear after pulverizing more than 30,000 tons of coal. The cast pegs formerly used required renewal after pulverizing 3500 tons. The carbide facings are joined to the forged pegs by means of a silver brazing alloy in conjunction with a semi-automatic gas burner. The brazing set-up has a capacity of 100 pegs per hr.*

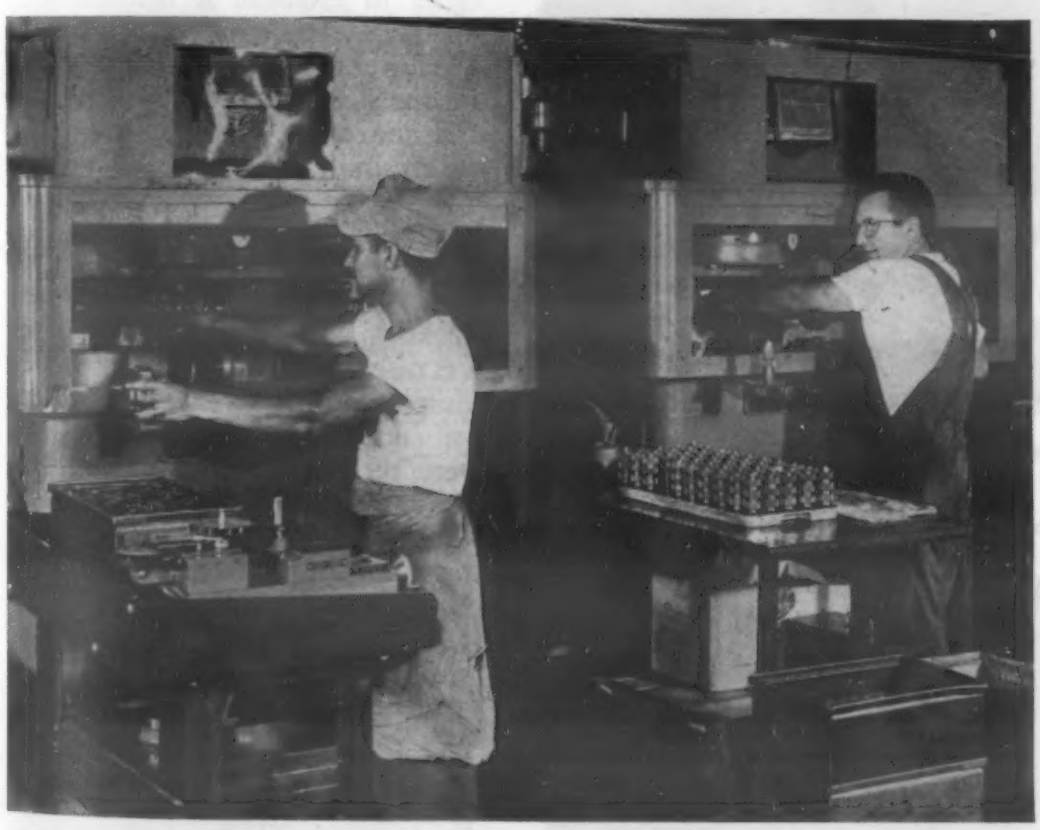


RUBBER AND FABRIC AIR HOSE *This extremely flexible and lightweight suction and discharge hose, specifically designed to handle hay, ensilage, dried leaves, street refuse and other comparable materials, is produced by the B. F. Goodrich Co. The hose is suitable for full vacuum and any discharge pressures where the material is to be conveyed by a moving air stream, and is one-ply rubber and fabric construction, wire reinforced, and has a smooth bore. Recommended uses include vacuum blowers, street cleaning equipment, and various machines for handling feathers, cotton, sawdust, corn husks and silk, vegetable peelings and other materials of similar nature in agriculture, canning plants and industrial applications.*

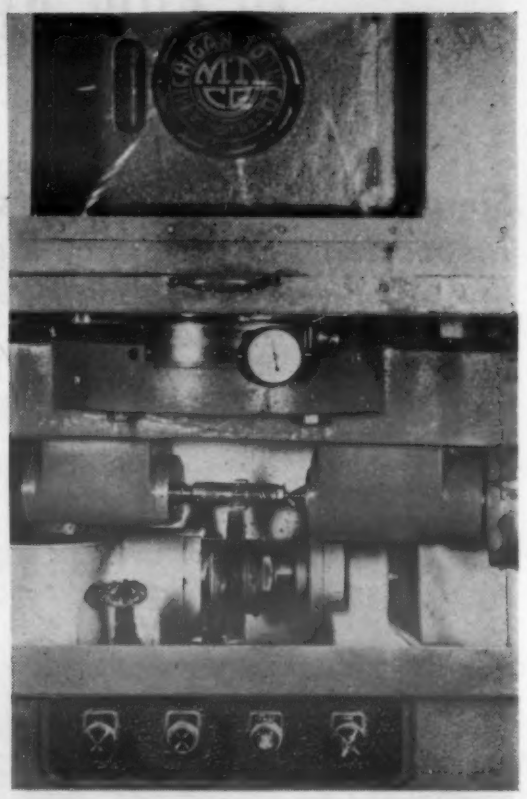
Gears of Different Materials Finished Without Tooling Change



Four types of gears, each of a different material, are finished without change in tooling.



View of two gear finishers in operation.



The Formica drive gear as well as the steel pinion are shaved on this machine without change in set-up.

• GEARS OF DIFFERENT materials are being precision finished on the same machines without change in tooling or cycle time at the new automatic washer plant of the Maytag Co., Newton, Iowa. The machines are manufactured by Michigan Tool Co., and are known as 870 "Underpass" rotary gear finishers.

One machine is used to finish two mating gears, one of gray iron, one malleable iron; the second machine is used to finish the main Formica drive gear and a steel pinion driven by a segment gear which gives the reciprocating action to the gyrator.

An idea of the precision obtained on the various gears, resulting not only in quiet washer operation but also in longer gear life, is given by the following figures:

Involute form . . within 0.0002-in. max.
Pitch line . . . . within 0.001-in. max.
Runout . . . . . within 0.0005 in.

Production quantities at Maytag currently are not such as to require the maximum output on each gear type possible on the gear finishers. Rather, the company has set these machines to a cycle time corresponding to the gear requiring the longest finishing time. The same cycle is used on gears which do not need as much time, avoiding the necessity of resetting the machine by shifting from one gear to another. Since "Underpass" finishing is employed—consisting of a single backward and forward movement of the cutter, while cutter and gear rotate in mesh—cutting time is nevertheless quite low and well under ½ min. per gear on all types.

Rigid Tests Check Quality of Pressure Welds in Low Alloy Steels

Simulated service tests, physical tests, and metallographic inspection are all depended on to assure reliable welds of maximum strength in aircraft landing gear.

by **A. I. NUSSBAUM,** Mond Nickel Fellow, London, England

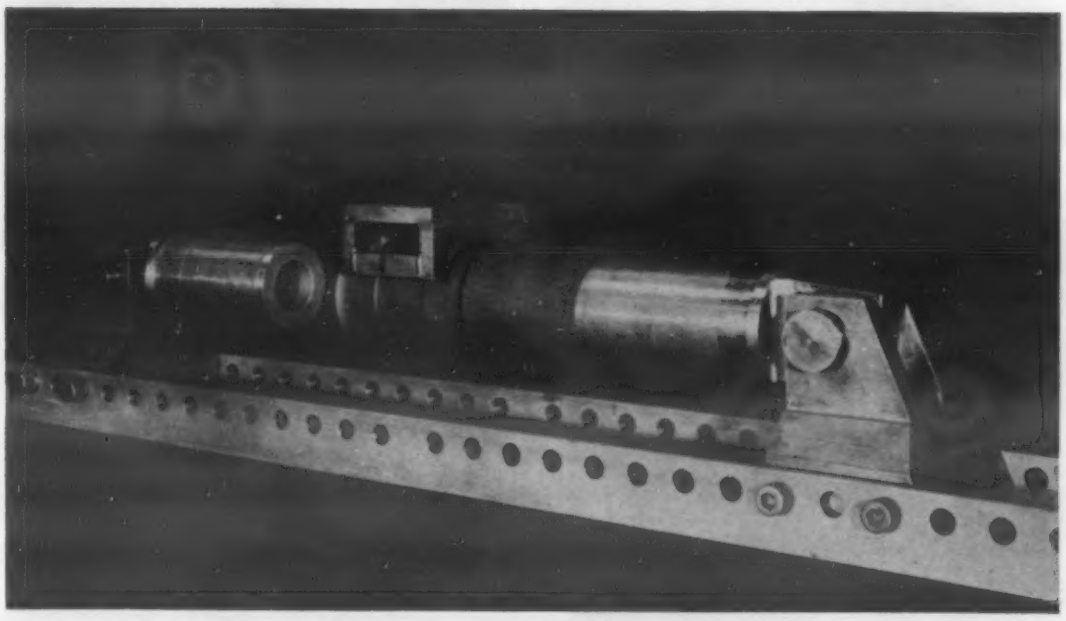
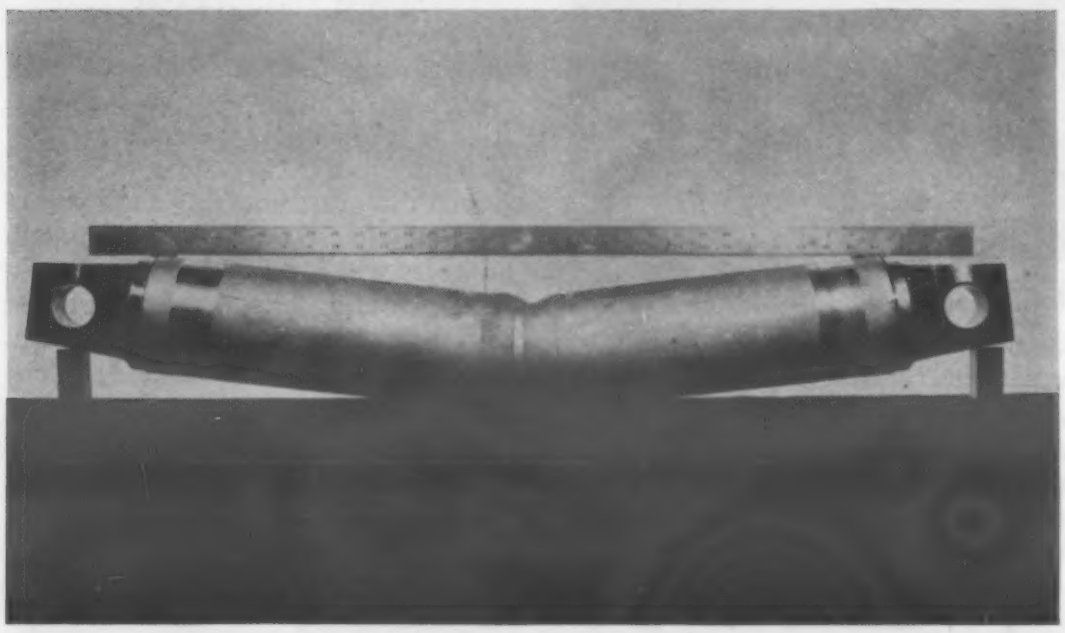


Fig. 1—Menasco's bend test set-up. (All photos courtesy of Menasco Manufacturing Co.)

Fig. 2—Bend test specimen buckles considerably before fracture occurs.



● FABRICATION OF aircraft gear units by means of oxyacetylene pressure welding requires reliable welds having maximum physical properties. The need for careful control of weld quality is reflected in the importance attached by Menasco Manufacturing Co. to the inspection and testing methods employed in connection with its Uniweld Process. This process, an application of the gas welding technique developed by Linde Air Products Co., was described in a preceding issue of MATERIALS & METHODS (April, p. 60). In this article, special attention will be paid to the inspection and testing procedures.

Physical Testing

At the present time, the company does not consider proof loading a particularly sensitive means of differentiating weld quality. Physical testing, nevertheless, is quite necessary for the correlation of metallurgical changes in welds with physical performance and for determining whether welds are usable for specific applications.

Several years ago, the company ran a group of static bend tests of welds using a range of "gathers" in order to establish a manufacturing tolerance. The range of gathers used was lower than that normally required for the size of that particular section, and the effect on weld strength is clearly indicated by the results. The welds were executed on NE 8735, a nickel-chromium-molybdenum low alloy steel, using a standard specimen with 3⅞-in. O.D. and ⅜-in. wall thickness. Pre-test heat treatment was carefully controlled to produce an ultimate tensile strength of 188,000 psi. and, subsequently, the specimens were turned down to 3¾-in. O.D. and 5/16-in. wall thickness. Full-size static bend testing was carried out by this company's standard method, employing the set-up illustrated in Fig. 1. In this fixture, the ends of the specimens are restrained by plugs which pivot freely in the supports, and loads are applied through a saddle straddling the weld.

The accompanying table presents the physical data and the gathers applicable to these bending tests of different welds. The weld with the lowest gather broke at the lowest load, strengths increasing progressively with increasing gather. Fig. 2 shows how a bend test specimen will buckle considerably before actual fracture occurs. Fracture in the weld plane *after* considerable deformation is typical of a certain proportion of

Fig. 3—Special drop testing tower used for landing gear assemblies.

Fig. 4—Landing gear in position for drop test.

pressure welds which possess the same ultimate bending strength and tube ductility as those which buckle or fail by rupture in the parent metal.

More important from the standpoint of continuing production control is the company's simulated service test. Completely assembled landing gear is tested in Menasco's specially constructed drop tower (Fig. 3) which accommodates even the largest units. Fig. 4 shows the main landing gear of a Glenn L. Martin 202 aircraft in position for the drop tests. This particular gear comprises as many as nine pressure welded joints.

Microscopic Inspection

The effect of contaminants is one of the major considerations in pressure welding and, of all contaminants, oxygen is thought by Menasco to be of the greatest importance. Oxygen contamination may take the form of a layer of oxide covering the weld faces or that of a solid solution at the weld. Initially, the only microscopic examination used by the company was one involving a nital etch of the plane of juncture. This yielded practically no information, however, as both good and poor welds appeared to be similar.

Since the company's metallurgists suspected the presence of oxygen in the flat fractures, they set out to develop an etching reagent for the detection of oxygen segregations in steel. The success of the alkaline chromate etch which resulted is illus-

Fig. 5—Micrograph made with nital etch, 100X, shows little oxygen segregation.

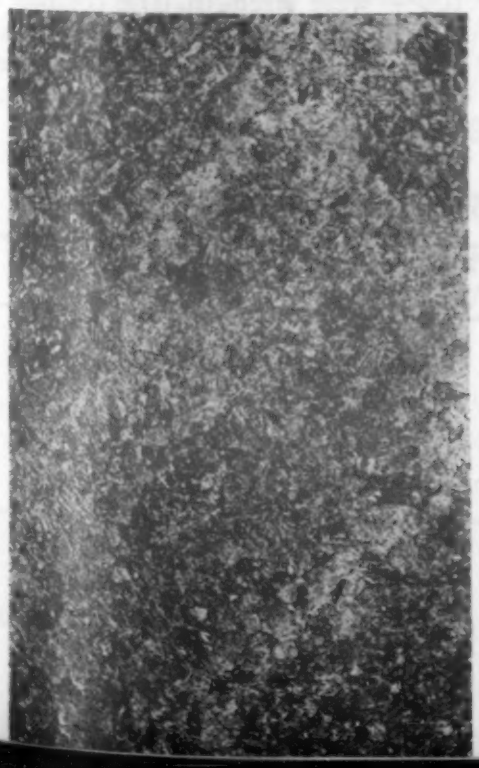


Fig. 6—Micrograph made with alkaline chromate etch, 100X, reveals substantial segregation.

Fig. 7—Micrograph, 100X. Alkaline chromate etch reveals even thin oxygen zones.

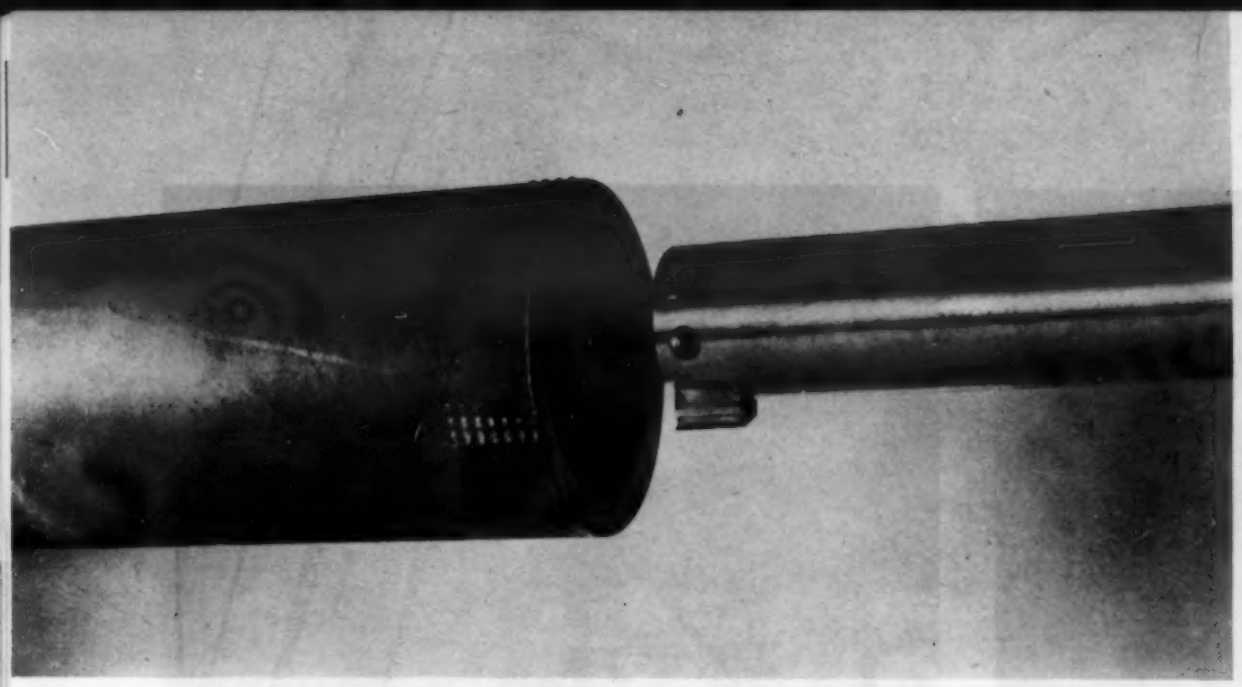


Fig. 8—Boring tool used to remove sample from weld for microscopic examination.

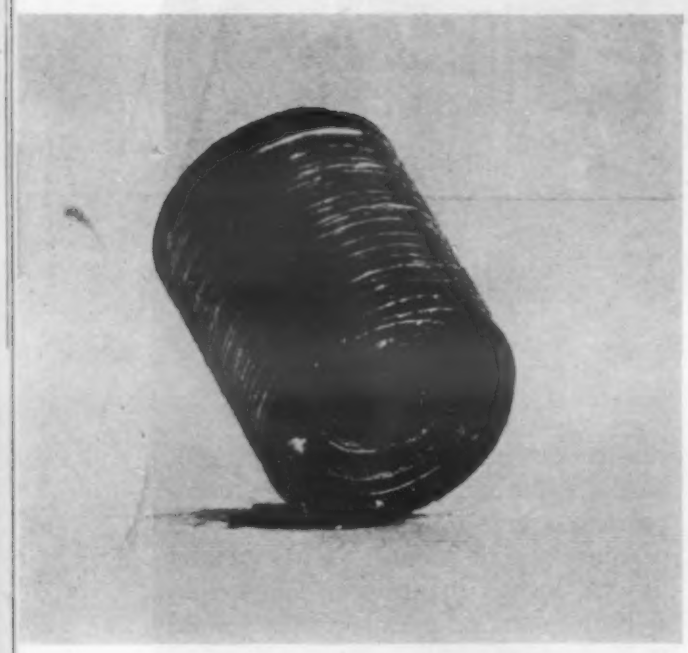


Fig. 9—Continuous chip removed from tube by boring tool.

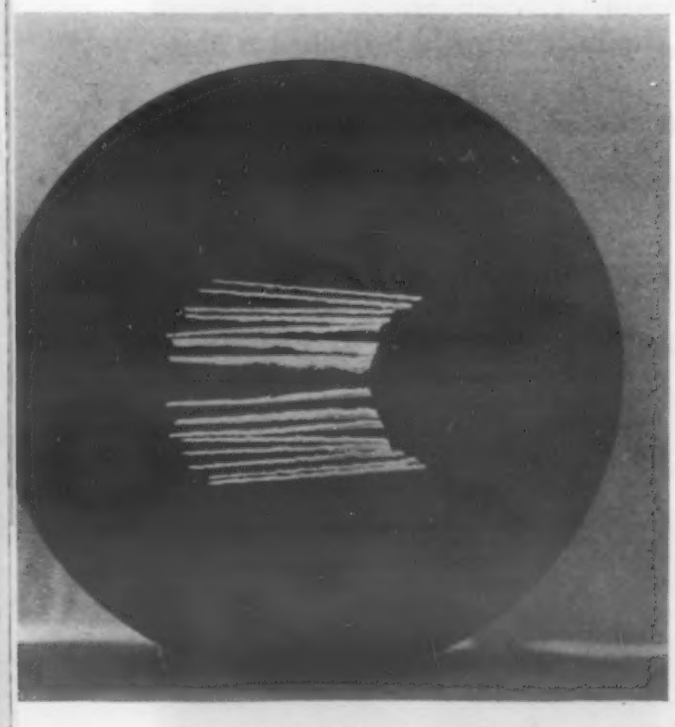


Fig. 10—Portion of sample chip mounted in Bakelite mold.

trated by Figs. 5 and 6—the 100X nital etch micrograph indicating hardly any segregation, and the 100X alkaline chromate etch micrograph showing up the segregation in sharp contrast. This alkaline chromate solution is now being used successfully on production Uniwelds, revealing even extremely thin zones of oxygen segregation at the weld plane. Thus Fig. 7 shows a 100X micrograph of a flash weld plane etched with the alkaline chromate solution; a conventional nital etch indicated no oxygen segregation.

The alkaline chromate etch (U.S. Patent Pending) is prepared and used in the following manner:

Weigh out 16 gm. of chromic acid. Add 145 ml. of distilled water. To the above solution add 80 gm. of caustic soda. Heat to boiling, and keep the solution boiling at 245 to 248 F. Place the sample to be etched into the boiling solution for 7 to 20 min. Remove sample quickly and place in a container of cold water. Rinse in a stream of cold water, then rinse in alcohol. Remove alcohol by rubbing the surface gently with a piece of soft tissue. The sample is then ready for microexamination. (Caution: The caustic soda should be added slowly. A minimum of 5 min. should be allowed for this operation or else the beaker should be placed in a cold water bath for rapid cooling. Because of the strong exothermic reactions involved, the solution tends to boil over during preparation. As sodium carbonate forms readily from the carbon dioxide in the air, it has been found desirable to use a fresh preparation each day.)

The various constituents found in steel do not etch at the same rate in alkaline chromate. Martensite is the most rapidly attacked and ferrite the most slowly. Even ferrite, however, etches much more rapidly than do zones of high oxygen content. The mass of the sample will affect etching time to a considerable extent since the sample itself must be heated as well as the solution. Variations in the composition of the solution are possible within certain limits and will still produce satisfactory results; this means that extremely accurate weighings are unnecessary.

For purposes of metallographic inspection, a boring tool (Fig. 8) is used to remove a coilspring-like continuous chip (Fig. 9) from the internal upset of the welded joint (U.S. Patent Pending); a portion of the chip is mounted in a mold (Fig. 10), by means of a small laboratory press induction-heated by low frequency current. Samples mounted in either Bakelite or Lucite have proved satisfactory. For best results, the Bakelite mount should be prepared by heating to 350 F at 5000 psi. pressure. It has frequently been found that Bakelite mounts prepared at 320 F showed inferior resistance to the strongly alkaline solution.

The alkaline chromate etch has formed the basis of this company's microscopic inspection system. A number of graded "standards" of metallographic appearance, depending on intensity of oxygen segregation, have been established to serve as a reference. Only welds conforming to one of the top three grades are accepted, although even the fourth grade is known to represent still 100% weld strength. The company's record of no service failures on Uniwelded joints can undoubtedly be attributed to this rather severe control procedure.

Results of Static Bend Tests on Standard Uniwelded Specimens

Gather (In.)	Failure Load (Lb.)	Test Modulus of Rupture (Psi.)	Type of Failure
0.264	66,800	201,000	Weld
0.285	79,500	239,000	Weld
0.294	90,500	272,000	Weld
0.304	98,800	300,000	Buckle
0.315	98,500	299,000	Buckle
0.334	98,300	299,000	Weld (after considerable deformation)

Materials & Methods Manual

This is another in a series of comprehensive articles on engineering materials and their processing. Each is complete in itself. These special sections provide the reader with useful data on characteristics of materials or fabricated parts and on their processing and application

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Stainless Steels—
Their Selection and Application

by T. C. Du Mond, Editor, Materials & Methods

Stainless steels aptly have been called the metals that paint themselves, due to their ability to instantaneously develop corrosion resistant films on their surfaces. With a notable increase in the use of stainless steels during the last decade, many more engineers are finding it necessary to know more about these versatile alloys. This manual tells, clearly and simply, what stainless steels are, how they vary one from the other, and what conditions govern their selection and application.

Contents

Introduction

Working with stainless steel is not difficult, it is just different.

That statement has been repeated millions of times. Despite its frequent repetition, the statement is not completely true. The selection of the proper stainless steel is difficult, until the selector becomes thoroughly familiar with all of the vagaries of this materials group.

Too many potential users of stainless steel fail to realize that "stainless" is a generic term that refers to 30 standard A.I.S.I. grades of steel and perhaps twice that many variations. Until this fact is completely understood, there can be no proper application of stainless steel except through blind luck.

Those who use stainless for the first time also must realize that the methods of fabricating stainless steel and how the ultimate product is to be used have the greatest possible effect upon the grade of stainless selected.

This manual will attempt to clarify these matters by trying to classify the steels according to their chemistry, according to their affinity for certain fabricating methods, and according to their ability to withstand certain types of service.

What Stainless Steels Are

The stainlessness of stainless steels is relative. Against certain types of corrosion these steels are superior in retaining clean, bright and unpitted surfaces. Under other conditions stainless steels are no better and sometimes actually worse than ordinary steels.

The least resistant stainless steel contains a minimum of 11.5% of chromium. It is theorized that this element provides the stainless characteristic by creating a thin, passive, oxide film on the metal's surface.

Even though the corrosion resistance of stainless steel is most generally accepted as their best feature, these steels offer many other favorable characteristics. From the available stainless steels, one can find some which are air hardening, others that develop good physical properties through work hardening, and others that offer exceptional resistance to scaling and oxidation at high temperatures. Certain stainless steels are easy to machine; others form remarkably well; still others are ideal for welded fabrication.

The uses for stainless steels range from simple architectural applications through a gamut of products to and including turbine buckets. One of the interesting new uses for stainless steel is in the fabrication of the metal portions of television picture tubes. Here stainless is used because a certain grade has a coefficient of expansion that matches closely that of glass—a requisite of the application.

In choosing a stainless steel, one should avoid using the methods which have worked satisfactorily for selecting carbon steels or tool steels—the point being that there are few instances where a specific grade of stainless can be chosen as being intended for one specific application.

Stainless steels have had a large part in permitting the processing industries to develop to the extent they have in recent years. Storage tanks such as these at Westinghouse Electric Corp. require vast tonnages of stainless steels.

Although the intent of this manual is to enable a prospective user of stainless steel better to understand the problems of selecting stainless steels and knowing why these steels perform as they do, it is by no means expected that a final choice should be made on the information contained here. Readers of this manual should be able to narrow a choice down to two or three steels. A final selection should not be made without doing two things:

1. Consulting the producer. The steel producer should be informed of all the conditions of use of the stainless. He should be told where and how the material will be used as well as how it will be fabricated.

2. Test thoroughly—in service—the steel you select in the product you are to make under actual service conditions. Likewise, test its fabricating characteristics under your shop conditions.

Page after page could be devoted to relating cases of where failure to do either or both of the above mentioned things caused substantial losses of time, money, metal and prestige.

Characteristics of Stainless Steels

Above all else, stainless steels are corrosion resistant. This characteristic is the only justification for their existence as a group. Fortunately, however, stainless steels do offer a wide range of other properties that enhance their value as engineering materials and widen the scope of their application.

In the thirty-odd stainless steels all of the properties vary somewhat, but in each the corrosion resistance is the most important single characteristic. The development of stainless steels is traced to a single steel which offered good resistance to atmospheric corrosion and to certain corrosive liquids and gases. Later, a little more strength was desired, so a new alloy was developed. Better machining qualities were sought, so another new alloy was developed. Better high temperatures properties were attained in other variations. So it went, until the one simple stainless steel grew into a big family of standard AISI steels and an even larger group of close relations.

Stainless steels as a group offer corrosion resistance, high strength, resistance to oxidation at high temperatures, hardness, ductility, good creep properties and other favorable properties. Not all of these properties can be found in any one steel, though. The same is true of the fabricating characteristics. Stainless steels can be welded, machined, drawn, cold worked, hot worked, spun, heat treated and otherwise fabricated by all normal fabricating procedures. Here again, not all properties are to be found in every stainless steel.

Corrosion Resistance

Oxidizing conditions are necessary to form and preserve the oxide film, which seems to be the reason for the so-called stainlessness of the stainless steels. With the 12% chromium, which is the lowest used in stainless steels, ordinary atmospheric conditions are sufficiently oxidizing to promote formation of protective films. Therefore, 12% chromium stainless steels resist atmospheric corrosion, although they will rust in time. As service conditions become less and less oxidizing, successively higher chromium contents become necessary to promote formation of protective films. Under a given set of corrosive conditions, as the chromium content is gradually increased, resistance to attack does not increase gradually, but occurs abruptly at the chromium content sufficiently high to allow the formation of a protective film. In addition, the use of nickel in quantities of 6 to 7% and over increases corrosion resistance.

A chromium content of 18% is sufficient to halt all but the most severe atmospheric corrosion. Ordinary 18:8 stainless grades have withstood the weather for well over a dozen years.

Stainless steel is excellent with nitric acid and other acids which are oxidizing in nature. These same steels are not good with reducing acids such as hydrochloric and hydrofluoric, and are readily attacked by all of the halogen salts (chlorine, bromine, fluorine and iodine). (In the dairy industry chlorine cleaners are used extensively in cleaning stainless steel, but a maximum of 40-min. exposure is the limit of use.) Sulfuric acid is on the borderline: under certain circumstances it is harmless, under others it promotes attack. The effects of salts and reducing acids, of course, vary with service conditions and concentration of the corrodent, as well as with the type of stainless involved.

To obtain maximum corrosion resistance in stainless steels, it is necessary to provide clean, smooth surfaces that are free from foreign materials and surface imperfections. In the case of hardenable grades of stainless steel, maximum corrosion resistance is achieved when the steel is in the heat treated condition. All stainless steels should be passivated.

Carbide Precipitation

When chromium-nickel stainless steels such as 302, 304, 309 and 316 are heated to between 800 and 1650 F, carbon within the grains migrates to grain boundaries and combines with chromium to form chromium carbide. This reaction is known as carbide precipitation, and the steel is said to be sensitized. When carbide precipitation occurs, metal adjacent to the grain boundaries is depleted of chromium in solution and the material is made susceptible to attack by corrosive acid solutions. Under normal atmosphere conditions, sensitization is not extremely harmful, but corrosion resistance is lowered.

Sensitization is dependent upon the ratio of the percentage of chromium to the percentage of carbon—the higher the ratio, the more stable the alloy. Said somewhat differently, the lower the carbon content the less is the danger of carbide precipitation. Where welding is anticipated, there are special stabilized grades of stainless which contain columbium or titanium to prevent the loss of chromium in the form of carbides.

Annealing at a temperature between 1900 and 2000 F will dissolve boundary carbides in sensitized steels, and rapid cooling keeps them in solution.

Resistance to Scaling

The chromium-oxide film which forms on stainless steels resists scaling. An oxide layer forms upon exposure to high temperatures and in its effective range protects the metal from rapid deterioration. How long such protection lasts depends upon the chromium content of the steel. The higher the chromium content, the more resistant to scaling will be the steel. Likewise, the safe heat level varies with the chromium content.

Scaling is accelerated in applications where the oxide layer is constantly being broken. For this reason, repeated heating and cooling with the accompanying expansion and contraction of the metal crack off oxide layers. The straight chromium grades of stainless have less thermal expansion than the chromium-nickel grades; therefore, they serve best for many applications where constant heating and cooling is involved.

Mechanical Properties

Stainless steels are strong, even in the annealed condition. In the chromium-nickel grades the tensile and yield strengths are not raised through heat treatment, but can be increased through cold work. The martensitic type of straight chromium stainless steels can be heat treated to high strength values. Since there is a close relationship between strength and hardness, hardnesses increase along with higher tensile strengths.

In the austenitic stainless steels, mechanical properties vary with the size and amount of cold working. Generally, the maximum tensile strengths are available in the smaller sizes and forms.

Certain of the stainless steels are highly ductile. For example, Type 302 offers elongation of from 50 to 60% in 2 in. This value corresponds with a 40% elongation for carbon steel of deep drawing quality.

Hardnesses in stainless steel range from 130 to 150 Brinell in annealed Type 302 to between 550 and 600 in heat treated Type 440-C.

High Temperature Properties

The strength of stainless steels varies, of course, with the alloy content, but most show rather good strength at high temperatures. For instance, Types 309 and 310 are often used at temperatures up to 2000 F, and most stainless steels show good short time strength at 1500 F. Compare this fact with that of carbon steels losing their usefulness above 900 to 950 F. Likewise, many stainless steels show a satisfactory resistance to creep at high temperatures.

Other Properties

None of the stainless steels could be considered good as far as thermal conductivity is concerned. Within the group, the chro-

Comparative Costs of Stainless Grades
(Type 410 = 100)

Type	Sheets	Cold Rolled Strip	Bar & Wire
301	114	113	124
302	114	122	124
302-B	120	133	128
303	—	—	135
304	120	130	130
305	127	139	135
308	137	144	148
309	158	189	180
310	180	233	244
316	161	204	200
317	194	244	248
321	138	165	148
347	152	180	167
403	109	124	113
405	105	119	107
406	115	141	120
410	100	100	100
414	102	102	100
416	102	124	102
420	123	161	124
430	108	102	102
430-F	—	—	104
431	109	104	102
440-A,B,C	123	161	124
446	152	222	141

mium-nickel steels offer the least thermal conductivity while the straight chromium stainlesses are best. For this reason, in applications where heat transfer is a problem, stainless cladding is applied to copper or some other material with better heat conductivity.

The rates of thermal expansion of stainless steels cover a wide range. With certain grades, expansion is less than SAE 1020 steel and in others more. Typical values are shown in the accompanying table of physical and mechanical properties.

The straight chromium stainless steels are magnetic, but the chromium-nickel grades are not. In the case of the latter steels, work hardening sometimes makes them slightly magnetic, but annealing causes them to again become nonmagnetic. As a group, stainless steels are poor conductors of electricity. In fact, certain grades are used as low cost resistance alloys. At 70 F, Type 410 stainless shows 22.5 microhms of resistance per cubic inch and Type 310 shows 30.5. These figures compare with 4.32 for SAE 1020 steel.

Fabricating Characteristics

Practically any of the usual fabricating processes can be applied to stainless steels. However, to fabricate, shape or finish them satisfactorily more exact procedures are required than is the case with ordinary mild steels.

Machining—All grades of stainless steel can be machined, but certain grades have been developed which are vastly superior in machinability. With most stainless steels slower speeds are required than for mild steels, and with the work-hardening grades deeper cuts are necessary. Certain stainless steels are gummy or stringy and affect results of machining. These points indicate why care is required in the choice of tool type and form as well as in the selection of machine speeds and feeds.

Drawing—Most grades of stainless steel can be formed by drawing. However, the chromium-nickel grades are best suited to deep drawing. All grades require considerably more power than for comparable draws in mild steel, because of higher tensile strengths and the chromium-nickel grades require greater die clearance than common steels.

Spinning—Spinning is practicable with most stainless grades, although Type 305 has been developed primarily for spinning. The straight chromium grades spin at about ⅔ the rate of mild steel, while the chromium-nickel grades spin at ¼ to ½ the rate used with copper. Some steels in the latter group require frequent annealing during spinning, because they work harden.

Upsetting—Cold forming is rather frequently used on most grades of stainless steel in the production of bolts, screws and parts of comparable shape. Forming of this type can be used on straight chromium steels in sizes up to ⅜ in. and 7/16 in. for the chromium-nickel grades. In sizes larger than those listed, hot forming is most satisfactory.

Welding—Most types of welding, brazing and soldering can be used to join stainless steels to themselves and to other materials. In the past, metal arc welding has been best for joining stainless steels, although inert-gas shielded arc welding is now being used more widely. The electrical characteristics of the stainless grades make them particularly suited to electrical resistance welding.

The chromium-nickel steels are the most readily welded, but most are susceptible to sensitization. Those steels in the ferritic group are subject to grain growth when subjected to high heat, so unless their other properties are needed they should not be chosen where welding is necessary. The same is true of the martensitic grades.

Silver soldering is used in joining stainless, but the heat required is close to the hardening range of the straight chromium steels and could cause grain growth in the ferritic types. When used with austenitic grades of stainless, the operation should be as rapid as is possible unless the stabilized grades are being used. Soft solders are also used extensively with stainless steels.

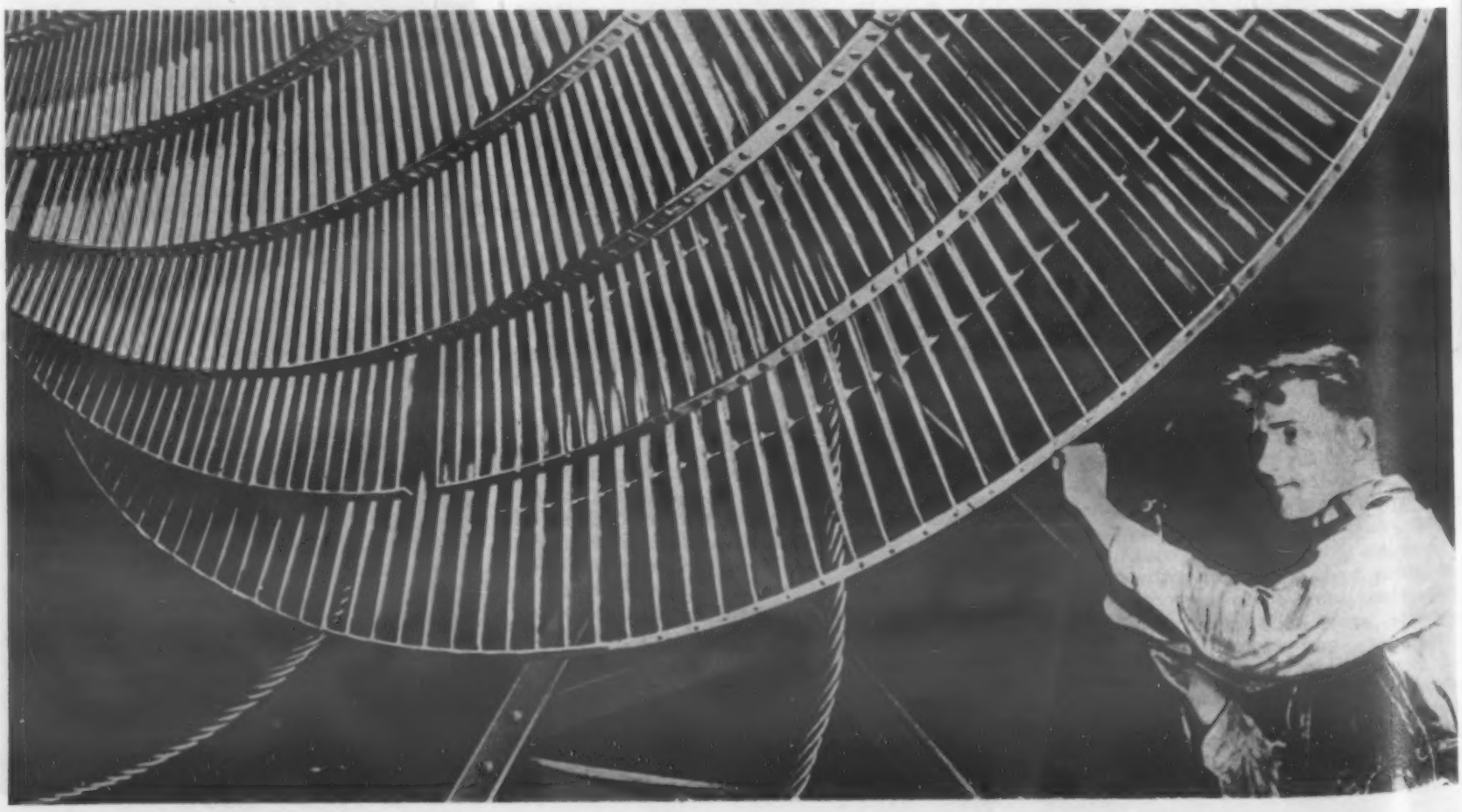
Forging—All standard stainless steels can be hot worked, although with some difficulty. As the alloy content increases, difficulty in forging increases. The chromium-nickel steels offer the best combination of forging properties, including a fairly wide range of forging temperatures. However, the ferritic grades of stainless are easiest to forge.

Finishing—Almost without exception, cleaning is necessary after the fabrication of stainless steels. The most satisfactory methods are vapor degreasing or by means of organic solvents. If either a brush or steel wool is used, precautions should be taken to see that the contact portions be made of stainless. All stainless steels should be passivated with nitric acid (10 to 20% at 120 to 130 F for 20 to 30 min.) to provide maximum corrosion resistance.

Most types of coating can be applied to stainless. They can be electroplated and electropolished, anodically etched, covered with porcelain enamel, and given colored coatings through the dying of surface oxides.

From the foregoing it can be seen that the properties of stainless recommend them for many uses. In selecting a stainless steel, great emphasis is—and should be placed on physical and mechanical properties and fabricating characteristics. Paying attention to these aspects alone can cause no serious trouble. However, in picking a stainless one should not ignore economics. In short, when a choice is narrowed down to two or three steels that can satisfactorily do the job, pick the one with the lowest alloy content, for it will be the least expensive.

The strength at high temperatures of many stainless steels recommends them for use in turbine applications for blades and buckets. *(Courtesy Carnegie-Illinois Steel Corp.)*



Stainless Steel—Wrought Forms and Uses

	Grade	Available Forms: Sheet	Strip	Plate	Bar	Wire	Outstanding Characteristics	Typical Uses
Austenitic	301	x	x	x	x	x	Strongly work hardening.	Light weight, high strength transportation equipment.
	302	x	x	x	x	x	Greater corrosion resistance, and less work hardening than Type 301.	General purpose applications.
	303	—	—	—	x	x	Free machining grade of 18:8.	Fastening devices, shafts, etc.
	304	x	x	x	x	x	Less heat sensitize than other 18:8 steels; used where heat is encountered.	Processing equipment.
	321	x	x	x	x	x	Stabilized with columbium to prevent carbide formation when heated. Good for welding.	Heavy equipment subjected to heat, or where no anneal is possible after welding.
	347	x	x	x	x	x	Same as Type 321 except titanium is used as stabilizing agent.	Same as Type 321.
	305	x	x	x	—	x	Work hardens to a minimum; useful for such processes as spinning.	Spun, drawn and cold headed parts.
	308	x	x	x	x	x	Highly resistant to corrosion and oxidation.	Welding rod.
	309	x	x	x	x	x	Properties somewhat superior to those of Type 308.	Annealing boxes and covers, furnace parts.
	310	x	x	x	x	x	Superior to both Types 308 and 309 in corrosion and oxidation resistance.	Welding rod, furnace parts.
	302-B	x	x	x	x	x	Silicon addition to 18:8 steels gives good corrosion and oxidation resistance.	Parts exposed to high temperatures.
	314	x	—	x	x	—	Similar—but superior to Type 302-B.	Same as for Type 302-B.
	316	x	x	x	x	x	Contains molybdenum for better corrosion resistance—particularly to pitting.	Equipment for paper and soap manufacture.
	317	x	x	x	x	—	Same as Type 316, except slightly more molybdenum. Highest corrosion resistance.	Processing industries equipment.
Ferritic	405	x	x	x	x	x	High dimensional stability.	Turbine blades, vessel lining, etc.
	406	—	—	—	x	x	Excellent resistance to high temperature oxidation.	Often used as electrical resistance alloy.
	430	x	x	x	x	x	Has good combination of properties at a relatively low cost.	Heat exchangers, furnace parts. 90% of automotive molding.
	430-F	—	—	—	x	x	A free-machining grade of Type 430.	Fastening devices.
	446	x	x	x	x	x	Has highest chromium content of all standard stainless steels. Best scaling resistance.	Heat resisting applications.
Martensitic	403	x	x	—	x	x	Turbine quality stainless steel—low in chromium content.	Turbine buckets, valves.
	410	x	x	x	x	x	Similar properties to those of Type 403.	Valve seats, pump shafts, etc.
	416	—	—	—	x	x	A free-machining 12% chromium steel.	Valve stems, bolts, screws.
	414	x	x	x	x	x	Has nickel added for toughness.	Furnace parts, pump shafts, etc.
	431	—	—	—	x	x	The most stainless of hardenable grades.	Marine shafting, aircraft fittings.
	420	—	x	—	x	x	A cutlery grade-high carbon provides hardness and corrosion resistance.	Cutlery, surgical instruments, springs.
	440-A	—	—	—	x	x	This and Types 440-B and 440-C have highest hardness of all stainless steels.	Valve seats and trim, cutlery.
	440-B	—	—	—	x	x	Has best combination of properties of 440 series.	Gages and instruments, springs.
	440-C	—	—	—	x	x	Greatest abrasion resistance, but least toughness of 440 types.	Bearings and bushings.

Standard Type Numbers, Chemical Composition Limits and Ranges for Stainless Steels

Type Number	Chemical Composition, Percent							
	C	Mn, Max.	Si, Max.	P, Max.	S, Max.	Cr	Ni	Other Elements
301	Over 0.08-0.20	2.00	1.00	0.040	0.030	16.00-18.00	6.00-8.00	—
302	Over 0.08-0.20	2.00	1.00	0.040	0.030	17.00-19.00	8.00-10.00	—
302 B	Over 0.08-0.20	2.00	2.00-3.00	0.040	0.030	17.00-19.00	8.00-10.00	—
303	0.15 max.	2.00	1.00	—	—	17.00-19.00	8.00-10.00	P, S, Se min. 0.07, Zr, Mo max. 0.60
304	0.08 max.	2.00	1.00	0.040	0.030	18.00-20.00	8.00-11.00	—
305	0.12 max.	2.00	1.00	0.040	0.030	17.00-19.00	10.00-13.00	—
308	0.08 max.	2.00	1.00	0.040	0.030	19.00-21.00	10.00-12.00	—
309	0.20 max.	2.00	1.00	0.040	0.030	22.00-24.00	12.00-15.00	—
310	0.25 max.	2.00	1.50	0.040	0.030	24.00-26.00	19.00-22.00	—
314	0.25 max.	2.00	1.5-3.0	0.040	0.030	23.00-26.00	19.00-22.00	—
316	0.10 max.	2.00	1.00	0.040	0.030	16.00-18.00	10.00-14.00	Mo 2.00-3.00
317	0.10 max.	2.00	1.00	0.040	0.030	18.00-20.00	11.00-14.00	Mo 3.00-4.00
321	0.08 max.	2.00	1.00	0.040	0.030	17.00-19.00	8.00-11.00	Ti 5 x C min.
347	0.08 max.	2.00	1.00	0.040	0.030	17.00-19.00	9.00-12.00	Cb 10 x C min.
403	0.15 max.	1.00	0.50	0.040	0.030	11.50-13.00	—	Turbine quality
405	0.08 max.	1.00	1.00	0.040	0.030	11.50-13.50	—	Al 0.10-0.30
406	0.15 max.	1.00	1.00	0.040	0.030	12.00-14.00	—	Al 3.50-4.50
410	0.15 max.	1.00	1.00	0.040	0.030	11.50-13.50	—	—
414	0.15 max.	1.00	1.00	0.040	0.030	11.50-13.50	1.25-2.50	—
416	0.15 max.	1.25	1.00	—	—	12.00-14.00	—	P, S, Se min. 0.07, Zr, Mo max. 0.60
420	Over 0.15	1.00	1.00	0.040	0.030	12.00-14.00	—	—
430	0.12 max.	1.00	1.00	0.040	0.030	14.00-18.00	—	—
430 F	0.12 max.	1.25	1.00	—	—	14.00-18.00	—	P, S, Se min. 0.07, Zr, Mo max. 0.60
431	0.20 max.	1.00	1.00	0.040	0.030	15.00-17.00	1.25-2.50	—
440 A	0.60-0.75	1.00	1.00	0.040	0.030	16.00-18.00	—	Mo 0.75 max.
440 B	0.75-0.95	1.00	1.00	0.040	0.030	16.00-18.00	—	Mo 0.75 max.
440 C	0.95-1.20	1.00	1.00	0.040	0.030	16.00-18.00	—	Mo 0.75 max.
446	0.35 max.	1.50	1.00	0.040	0.030	23.00-27.00	—	N_2 0.25 max.

Physical and Mechanical Properties

Type	302	303	321	347	309
Structure	Austenitic	Austenitic	Austenitic	Austenitic	Austenitic
Melting Point, F	2550	2550	2550	2550	2530
Magnetic	No	No	No	No	No
Electrical Resistivity, Microhms/In.^{3}, 70 F	28.6	28.6	28.0	28.0	31.5
Modulus of Elasticity, 10^6 Psi.	29	29	29	29	30
Linear Coefficient of Ther. Exp., per Deg. F x 10^{-6} (0-600 F)	9.5	9.5	9.4	9.4	9.5
Thermal Conductivity, Btu./Sq.Ft./Hr./F/In., 200 F	113	113	112	110	121
Tensile Strength, Psi.					
Annealed	90/100,000	85/95,000	90/100,000	90/100,000	95/105,000
Cold Worked	100/180,000	—	100/180,000	100/180,000	—
Heat Treated	—	—	—	—	—
Yield Point, Psi.					
Annealed	35/45,000	30/40,000	35/45,000	35/45,000	35/45,000
Cold Worked	50/150,000	—	—	—	—
Heat Treated	—	—	—	—	—
Elongation in 2 In., %					
Annealed	55/65	45/55	50/60	50/65	40
Cold Worked	—	—	—	—	—
Heat Treated	—	—	—	—	—
Reduction in Area, %, Annealed	60/70	55/60	60/75	60/70	50
Impact Strength, Izod Value, Ft.-Lb., Annealed	115/140	75/80	70/120	115/140	—
Hardness					
Brinell Number, Annealed	140/150	160	140/150	170/200	170/200
Cold Rolled	180/375	180/375	180/300	180/300	180/300
Heat Treated	—	—	—	—	—
Rockwell Number, Annealed	74/87B	74/87B	87/94B	74/87B	87/94B
Cold Rolled	89B/38C	89B/38C	89B/32C	89B/32C	89B/32C
Heat Treated	—	—	—	—	—
Creep Strength for Life of 10,000 Hr. with 1% Elongation					
at 1000 F, Psi.	18.3	18.3	25	25	15
at 1100 F, Psi.	11.5	11.5	20	20	10
at 1300 F, Psi.	3.5	3.5	10	10	4.5
at 1500 F, Psi.	0.85	0.85	3	3	1
Strength at Elevated Temperatures, Short Time Tests, Psi.					
at 1300 F	37.5	37.5	45	45	55
at 1500 F	22.3	22.3	30	30	34
at 1700 F	12.0	12.0	18	18	16

Standard Stainless Steel Types and Grades

In attempting to classify stainless steels it is usually found most satisfactory to group them according to chemical composition and characteristics. In general use there are three classifications which take their names from the type of metallographic structure found in the steels.

All standard stainless steels have a minimum of 12% chromium, and the classifications used correspond roughly with the chromium or chromium and nickel contents. The classifications are: austenitic, ferritic and martensitic. Often for the sake of simplicity the steels are identified by the chromium content. Thus, one steel may be known as a 27-chromium steel. The greatest use of this means of identification is in connection with the 18 chromium-8 nickel steels which are almost universally known as 18:8 steels.

Austenitic stainless steels are work hardening and include the widely applied 18:8 family of steels. They are alloys of iron, chromium (18 to 30%) and nickel (6 to 20%). *Ferritic* stainless steels are, in effect, stainless irons and do not harden appreciably either by cold working or through heat treatment. This group contains 18 to 30% chromium and the carbon content is kept low. Corrosion resistance of the steels in this group is high. *Martensitic* stainless steels are straight chromium steels and are air hardening. They contain chromium in the 12 to 17% range, and carbon content covers a wide range.

Although the brief descriptions to follow will help to show the differences between the various standard stainless steels, the accompanying illustrations showing the development of the various grades will aid in understanding why so many grades exist.

Austenitic Stainless Steel Grades

The chromium-nickel (austenitic) stainless steels are not hardenable by heat treatment. They do harden through cold working to varying degrees, depending largely upon the alloy content. Severely cold worked steels in this group show tensile strengths up to 300,000 psi. Fully annealed steels within the group drop down in tensile strengths to about 80,000 psi. In these steels the chromium content ranges from 16 to 26% and nickel from 6 to over 20%.

Steels in the austenitic group are nonmagnetic, although cold work causes them to become somewhat magnetic. The magnetic condition can be corrected by annealing. These steels are extremely tough and ductile, even at low temperatures. The ductility, of course, gives the chromium-nickel steels favorable cold working properties. This group can be joined by the normal joining processes, but only the free machining grades are cut at highest speeds.

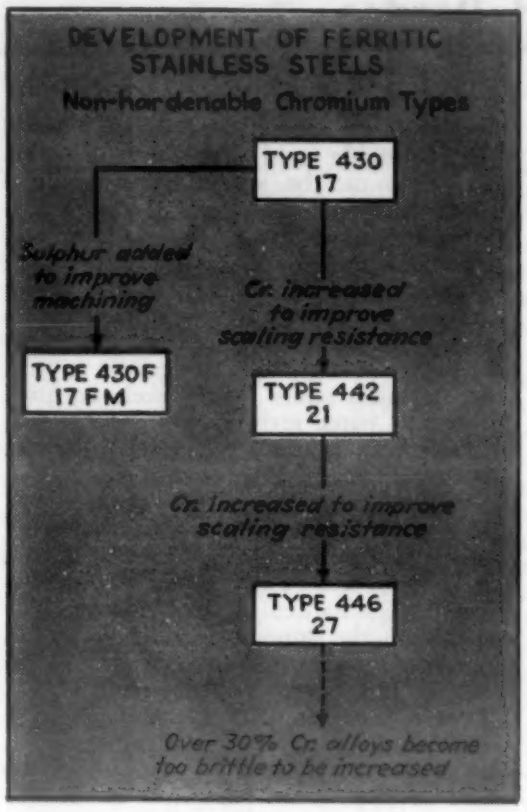
The austenitic steels, because of their ease of forming, as well as for their other properties, are the most widely applied stainless steels. Type 302, one of the familiar 18:8 steels, is the one grade most broadly applied of all stainless steels. These steels are used for aircraft parts, architectural uses, chemical processing equipment, household items, fastening devices, transportation equipment, marine fittings and many other applications.

Type 301—Here is the lowest alloy combination within this group of steels, having only 7% nickel. This particular alloy is strongly work hardening. It is commercially available in the annealed condition and in four cold-worked tempers, and is used extensively on transportation equipment.

Type 302—This 18:8 grade is the most widely used of all the stainless steels. It does not work harden to quite the same degree as Type 301. This steel is suitable for deep drawing as well as for most other fabricating processes. Where heat is to be a service condition, or where welding is involved sensitization must be guarded against.

of Representative Stainless Steels

316	430	430-F	446	410	416	420	440-A	440-C
Austenitic	Ferritic	Ferritic	Ferritic	Martensitic	Martensitic	Martensitic	Martensitic	Martensitic
2500	2710	2650	2650	2725	2700	2650	2650	2650
No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
28.5	26.0	22.5	26.5	23.0	23.0	20.0	—	—
28.5	29	29	29	29	29	29	29	29
9.0	5.6	5.6	5.5	6.1	6.1	5.9	5.9	5.9
108	156	156	145	173	160	—	—	—
90/100,000	75/85,000	70/90,000	80/90,000	100/120,000	70/85,000	95/105,000	90/100,000	—
—	—	90/130,000	—	—	—	—	—	—
—	—	—	—	100/185,000	80/160,000	150/300,000	125/300,000	285,000
35/45,000	35/45,000	40/55,000	55/65,000	80/100,000	40/50,000	60/70,000	50/60,000	—
—	—	65/130,000	—	—	—	—	—	—
—	—	—	—	60/170,000	70/180,000	120/200,000	100/250,000	275,000
50/60	30/40	20/30	20/30	25/35	20/35	25/30	25/35	—
—	2/20	2/20	—	—	—	—	—	—
—	—	—	—	10/30	10/25	2/12	1/15	2
60/75	50/60	40/55	40/50	50/75	8/65	5/60	3/45	10
70/120	20/60	5/60	1/5	20/45	15/35	5/15	3/6	1/5
170/200	150/190	145/185	160/200	135/155	145/195	180/200	180/205	—
180/300	185/270	185/270	—	—	—	—	—	—
—	—	—	—	160/400	190/350	300/600	285/625	—
87/94B	81/92B	80/90B	85/94B	85/95B	80/95B	90/94B	90/95B	—
89B/32C	90/105B	90/105B	—	—	—	—	—	—
—	—	—	—	10/40C	8/35C	32/58C	30/60C	57C
25	8.5	8.5	—	13	13	—	—	—
20	5	5	3.5	5	5	—	—	—
10	1.4	1.4	0.8	1.5	1.5	—	—	—
3	0.6	0.6	—	0.7	0.7	—	—	—
45	19	20	22.5	17	17	27	—	—
30	9	10	11	8.4	8.4	14	—	—
18	7	6	6	8	8	10	—	—



Type 303—Sulfur, selenium and sometimes phosphorus are added to Type 302 stainless to produce this grade. These elements make the steel free machining. With controlled conditions and using selenium rather than sulfur and with nickel on the high side, Type 303 is useful for cold heading and upsetting. Corrosion resistance is lowered through the use of either sulfur or selenium.

Type 304—In this grade of stainless, carbon is held to less than 0.08% as a means of minimizing sensitization. Therefore, it is sometimes picked in preference to Type 302 where considerable welding is involved and service conditions are moderately severe.

Type 321—

Type 347—Titanium and columbium are used in these 18:8 steels, respectively, to stabilize them against heat sensitization. These steels are suggested when welding is to be used in fabrication and where annealing is not possible. Likewise, they are useful where the product will be heated to the sensitizing temperatures during service.

Type 305—In this steel the nickel content is raised to 12%. This steel work hardens to the minimum extent, therefore is useful for such work as requires spinning, where work hardening is not desirable.

Type 308—

Type 309—

Type 310—These are 20:10, 25:20 types of stainless. They provide the highest degree of corrosion and oxidation resistance, with both of these characteristics being best in Type 310. Sensitization is possible in all these grades, but least likely in Type 310. Because of their high alloy content, these steels are expensive. Type 310 is frequently used to make welding rod, as it produces ductile weld metal. These alloys resist oxidation up to 1900 to 2000 F.

Type 302-B—

Type 314—Adding approximately 2% of silicon to 18:8 produces Type 302-B, which has higher resistance to oxidation at high temperatures. The silicon also gives added protection against the corrosive action of sulfuric acid. Adding the same amount of silicon to Type 310 produces Type 314. Its properties correspond to those of Type 302-B, but are superior in all cases.

Type 316—

Type 317—Molybdenum is included in these alloys to provide an 18:12:2.5 and a 19:12:3.5 alloy. These grades are outstanding for their creep strength at high temperatures. These molybdenum bearing steels are particularly resistant to pit-type corrosion.

Ferritic Stainless Steel Grades

Steels in the ferritic group are in somewhat of a middleground between the austenitic and the martensitic stainless steels as far as properties are concerned. Ferritic stainless steels are non-hardenable, but are magnetic. They have poor thermal conductivity, and their mechanical properties fall between those of the other two classes of stainless. Ferritic stainless steels usually are chosen for their corrosion and oxidation resistance rather than for their high strength properties.

Chromium content in this group ranges from 18 to 30%. Uses for materials falling in this group range from cast-in turbine blades through such applications as grid resistors and heating elements, furnace parts and fastening devices.

Type 405—Type 405 alloy contains aluminum. The aluminum makes this alloy less susceptible to air hardening after welding. The material is used where dimensional stability and corrosion resistance are desired and where high strength and hardness are not needed.

Type 430—This is the most widely used ferritic stainless, it is ductile and can be readily roll formed, leaving the rolls with a high lustre. Therefore, Type 430 is used widely for automotive body trim and similar use. Steels made to the low chromium range have good weldability, strength and hardness, but suffer in corrosion resistance. Higher chromium content gives better corrosion resistance but the other properties suffer. Type 430 has better heat resisting properties than some of the more highly alloyed grades in certain applications up to 1500 F, and is somewhat less expensive.

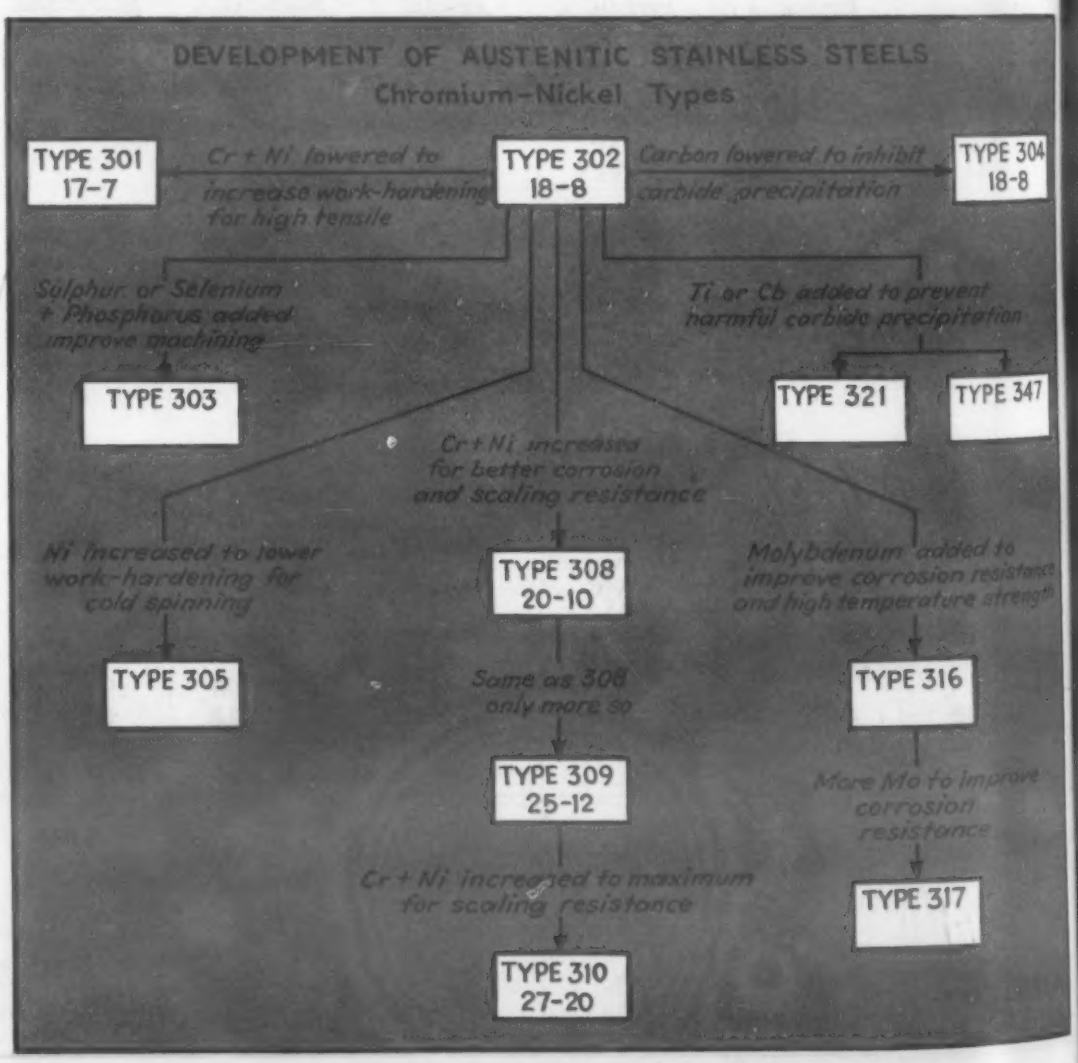
Type 430-F—Sulfur is added to the composition of Type 430 stainless to provide better machinability. This property is achieved without much sacrifice of other properties.

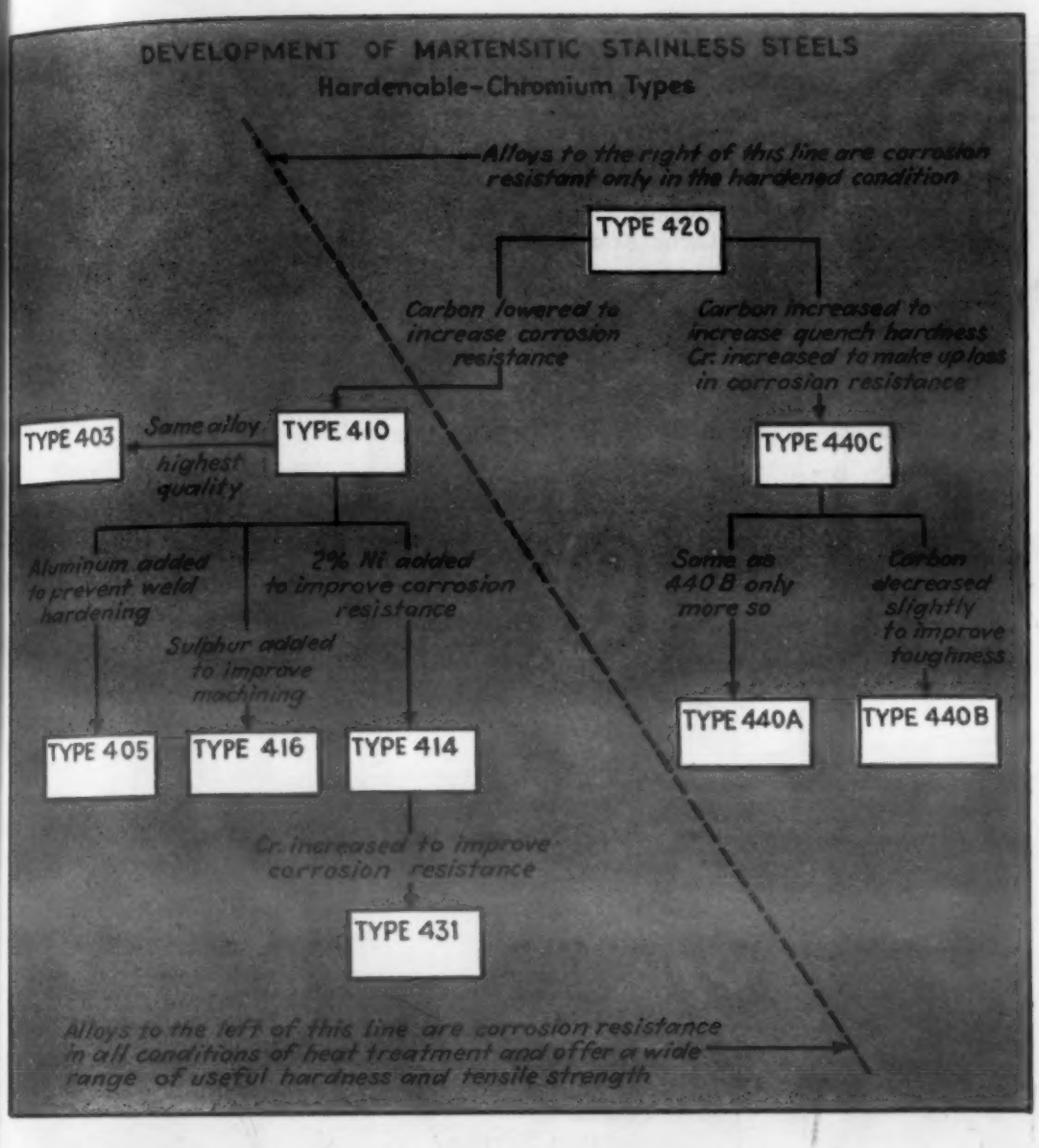
Type 446—With chromium at 23 to 27%, this alloy has the highest content of that alloying element in the commercial series of stainless steels. The chromium content gives this grade the greatest corrosion and oxidation resistance of the straight chromium grades. With this alloy grain growth is a constant threat when steady heat is applied during service. Type 446 can be hot worked, resists sulfurous gases, but it is low in ductility and is notch sensitive after cooling to room temperature subsequent to long exposure to high temperatures.

Martensitic Stainless Steel Grades

The martensitic stainless steels are straight chromium steels, most of which use no nickel. They are heat-treatable and provide best mechanical and corrosion resistant properties when hardened. Most steels in this group are air hardening, although oil quenching is sometimes used to give superior properties.

Steels of the martensitic type are used for mechanical parts more than are the stainless steels in the other two groups. Thermal conductivity of this group is the best of the





stainlesses, but is still poor. The steels are electrically resistive and have relatively poor reflectivity.

In the annealed condition these steels offer tensile strengths from 70,000 to 105,000 psi. Hardened, the ranges are elevated to 200,000 and 285,000 psi., respectively.

Steels in this general category are used for valves, turbine buckets, pump parts, bearings, marine propeller shafting, cutlery, springs, dental and surgical instruments, and many other parts of a similar nature where high mechanical strength is required.

Type 403—

Type 410—Both of these steels are of the same composition. Type 403 is made from ingots which are somewhat more carefully processed. Both steels have just enough chromium to fall within the stainless category and have a low carbon content. The steels are air hardening, and combine hardness with corrosion resistance. Type 403 is known as turbine quality stainless.

Type 416—This stainless grade is a free machining 12% chromium steel. Its properties correspond reasonably well with those of Type 410, except that this steel is somewhat less ductile and a little less resistant to corrosion.

Type 414—

Type 431—Both of these chromium steels have nickel added for toughness. They thus become 12:2 and 16:2 steels, respectively. In addition to providing toughness, the nickel provides a slight increase in corrosion resistance over nickel-free steels of the same chromium content. Type 431 is the most stainless of the hardenable grades of stainless.

Type 420—A cutlery grade of stainless steel, Type 420 has a high carbon content. This alloy has good corrosion resistance, high hardness, toughness and good abrasion resistance. The carbon range is from 0.30 to 0.40. It is used extensively for springs.

Type 440-A—

Type 440-B—

Type 440-C—With carbon contents of 0.60, 0.80 and 1.00%, respectively, these steels have hardnesses surpassing those of all other grades of stainless steel. The chromium content is between 16 and 18%. Type 440-C has maximum abrasion resistance, but somewhat less toughness and corrosion resistance than the other two 440 types.

Special Stainless Steels

During the last few years several important stainless steels have been developed. These are too new to have been accepted as standard American Iron & Steel Institute grades, but they do fit a definite need.

Armco Steel Corp. and Carnegie-Illinois Steel Corp. are both producing precipitation hardening stainless steels. These steels combine the best properties of the chromium-nickel and the straight chromium stainless grades. They are readily fabricated by forming or machining, and they can be heat treated to hardness approaching those obtained in the Type 440 stainless steels. Their corrosion resistance compares with the austenitic stainless grades, and they are not subject to intergranular corrosion when subjected to heat.

The same two companies, Carnegie-Illinois Steel Corp. and Armco Steel Corp., are also producing 18:8 stainless steels with the carbon content held to a maximum of 0.03%. The low carbon level in these steels makes them ideally suited for welding applications where annealing is not possible or desirable. In effect they prove less expensive as an alternative to the stabilized grades. However, these steels will become sensitized upon continued exposure to temperatures between 750 and 1600 F. In most other respects the low carbon stainless steels exhibit properties which correspond closely to the 18:8 grades of stainless.

One other special stainless should be listed here. It is known as Stainless #20 and is produced by Carpenter Steel Co. The steel is the wrought version of Durimet 20, a "super corrosion resistant" cast stainless. The wrought material is now available in all standard forms. Its outstanding characteristic is its resistance to the corrosive effects of sulfuric acid. Stainless 20 has an exceptionally high (29%) nickel content and contains 3% copper. Mechanical properties correspond to those of the 18:8 steels.

One of the newer uses of stainless is for structural parts of ships, such as these destroyer stacks made by Heintz Manufacturing Co.

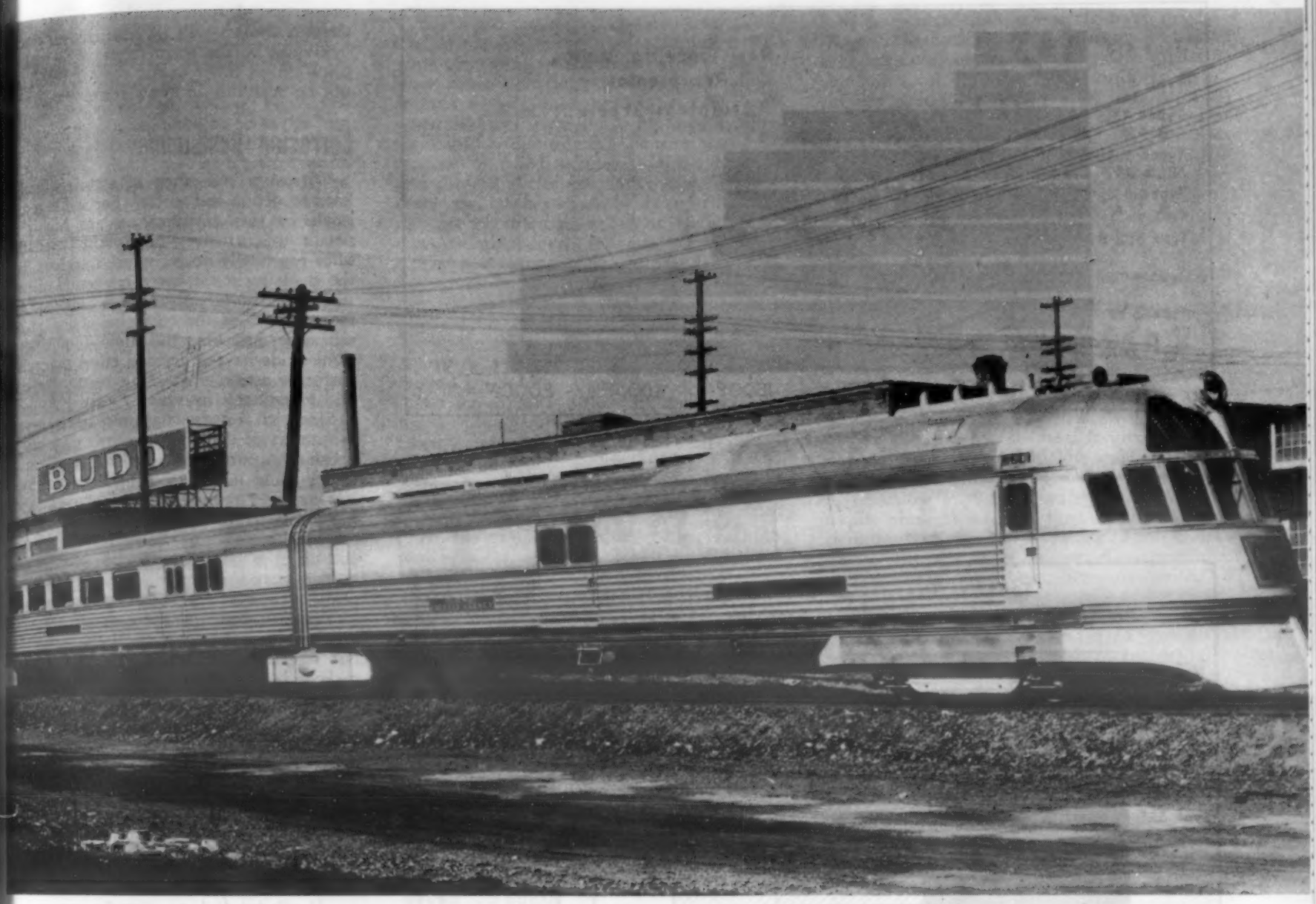
Corrosion Resistance of Representative Stainless Steels

Corrosive Media	F	430	302	316
Acetic Acid				
5%	70	A	A	A
5%	180	—	A	A
10%	70	A	A	A
10%	180	—	A	A
20%	70	A	A	A
20%	180	—	A	A
50%	70	B	A	A
50%	180	—	B	A
80%	70	A	A	A
80%	Boiling	—	C	A
100%	70	A	A	A
100%	180	—	A	A
100%—150-Lb. Pressure	400	—	C	B
Acetone	Boiling	A	A	A
Acetylene	70	A	A	A
Alcohol-Ethyl	70	A	A	A
Alcohol-Methyl (Methanol)	70	A	A	A
Alcohol-Methyl (Methanol)	150	B[1]	B[1]	A
Alum—2% and 10%	70	A[1]	A[1]	A
2% and 10%	Boiling	B[1]	A[1]	A
Sat.	70-212	B[1]	A[1]	A
Aluminum	Molten	C	C	C
Ammonia				
Any Conc. Aqueous Sol.	70-212	A	A	A
Anhydrous	70	A	A	A
	Hot	C	C	C
Ammonia Liquor	70	—	A	A
Aniline—3%	70	A	A	A
Conc. Crude	70	A	A	A
Arsenic Acid	150	—	A	A
Baking Oven Gas	—	A	A	A
Barium Carbonate	70	A	A	A
Benzol—Commercial	70 & Hot	A	A	A
Pure	176	A	A	A
Blood (Meat Juices)	Cold	A[1]	A[1]	A
Borax 5%	Hot	A	A	A
Buttermilk	70	A	A	A
Carbon Tetrachloride				
CP	70 & Boil.	A	A	A
Commercial	70	A[1]	A[1]	A
Moist at High Temp.	—	C	C	C
(Vapors Refluxed)	Boiling	C	C	C
Chlorinated Water—Sat.	70	C	C	B[1]
Chlorine—Dry Gas	70	B	B	B
Moist Gas	70	C	C	C
Gas	212	C	C	C
Cider	70	A	A	A
Citric Acid				
5% Still	70 & 150	A	A	A
15%	70 & Boil.	A	A	A
Sat.	Boiling	—	B	B
5% (at 45 Psi.)	284	—	C	A
25% Sol.+0.6% H_2SO_4	68	—	A	—
25% Sol.+0.75% H_2SO_4	68	—	C	—
50% Sol.+0.6% H_2SO_4	68	—	A	—
Coca-Cola Syrup (Pure)	70	A	A	A
Coffee	Boiling	A	A	A
Copper Nitrate	70 to Hot	A	A	A
Copper Sulfate (All Conc.)	70-150	B[2]	A	A
Creosote—(Coal Tar)	Hot	—	A	A
(Oil)	Hot	—	A	A
Developing Sol. (Photographic)	70	A	A	A
Epsom Salt	Hot & Cold	A	A	A
Ether (Ethyl)	70	A	A	A
Ethyl Chloride	70	A	A	A
Fatty Acids	70	A	A	A
Food Pastes	—	A	A	A
Fruit Juices	70	A	A	A
Fuel Oil	Hot	—	A	A
Furfural	70	—	A	A
Gasoline (Benzine)	70	A	A	A
Gelatine	—	A	A	A
Glue Dry	70	A	A	A
Glycerine	70	A	A	A
Hydrochloric Acid All Conc.	70	C	C	C
Hydrogen Peroxide, Acid Free	70 & Boil.	A	A	A

Corrosive Media	F	430	302	316
Ink	—	—	A[2]	A
Iodine	70	C	C	C
Kerosene	70	A	A	A
Ketchup	70	A[1]	A[1]	A
Lactic Acid— 1%	70 & Boil.	A	A	A
5%	70	A	A	A
5%	150	A	B	A
5%	Boiling	B	B	A
10%	70	A	A	A
10%	150	—	C	B
10%	Boiling	C	C	B
Conc.	Boiling	—	A	A
Conc.	70	—	C	B
Lard	70	A	A	A
Lead	Molten	A	A	A
Lysol	—	C	C	C
Mayonnaise	70	—	A[1]	A
Mercury	—	A	A	A
Milk (Fresh or Sour)	Hot or Cold	A	A	A
Molasses	—	A	A	A
Mustard	70	B[1]	A[1]	A[1]
Naphtha Crude or Pure	70	A	A	A
Nitric Acid—5-50%	70 & Boil.	A & B (Boil.)	A	A
Conc.	70	A	A	A
	Boiling	C	B	B
Fuming Conc.	70	A	A	A
Fuming Conc.	110	A	A	A
Fuming Conc.	Boiling	C	C	C
Oils Crude	Hot & Cold	A[2]	A[2]	A[2]
Oils (Vegetables & Mineral)	—	A[2]	A[2]	A[2]
Paraffin	Hot & Cold	A	A	A
Picric Acid	70	A	A	A
Rosin	Molten	A	A	A
Sauerkraut Brine	—	—	C	A
Sea Water	—	B[1]	A[1]	A[1]
Sewage	—	—	A[2]	A[2]
Silver Chloride	—	C	C	C
Silver Cyanide				
Electroplating Solution	—	—	A	A
Silver Nitrate	—	A	A	A
Soaps	70	A	A	A
Sodium Bicarbonate	70 & 150	A	A	A
Sodium Carbonate—5-50%	70 & Boil.	A	A	A
Molten	1650	—	C	C
Sodium Chloride (All Conc.)	—	A[1]	A[1]	A[1]
Sodium Peroxide	212	—	A	A
Soy Bean Oil	—	—	A	A
Stannic Chloride Solution	Boiling	C	C	C
Steam, CO_2 and Air	—	B	A	A
Stearic Acid—Conc.	176	A	A	A
Sugar Juice	—	A	A	A
Sulfur	500 Molten	A	A	A
Sulfur Dioxide—Gas Moist	70	B[1]	A[1]	A
Gas Dry	575	A	A	A
Sulfuric Acid— 5%	70	B	B	A
	Boiling	C	C	C
10%	70	B	B	A
	Boiling	C	C	C
50%	70	C	C	B
	Boiling	C	C	C
Conc.	70	A	A	A
	Boiling	B	B	B
Conc. Fuming	300	C	C	C
	70	—	B	A
Syrup	—	—	A	A
Tartaric Acid	70	B	A	A
	150	C	A	A
Tin	Molten	C	C	C
Tomato Juice	—	—	A	A
Trichlorethylene, Pure	68	B[1]	A[1]	A[1]
Tung Oil	—	—	A	A
Varnish	70-Hot	A	A	A
Vegetable Juices	—	A	A	A
Vinegar	70	A	A	A
Vinegar Fumes	—	A	A	A
Zinc	Molten	C	C	C

A—Usable under most conditions.
B—Subject to attack but can be used with caution.
C—Attack too severe to use.

[1] *Subject to pitting.*
[2] *Subject to attack when H_2SO_4 is present.*



After 13 years of constant service, the stainless steel trains of the Burlington Zephyr were taken apart for overhaul recently. When stripped down, the internal stainless steel structure was examined to see how it has stood up. No evidence of corrosion was found on the stainless steel parts. (Courtesy Allegheny Ludlum Steel Corp.)

Selecting Stainless Steels for End Service Requirements

At the risk of becoming repetitious, it must be restated that the principal reason for using a stainless steel, at least in wrought form, is for its corrosion resistance. There are many instances where other service requirements become important, but, with the exception of high temperature strength and scale resistance, the other requirements are secondary to corrosion resistance as reasons for buying stainless steels.

As a class, stainless steels offer high strength, resistance to scaling and oxidation at high temperatures, good short time strength at high temperatures, and high hardness and abrasion resistance. Of course, not all of these properties can be had to the highest degree in any one steel. Under certain circumstances, then, it becomes necessary to make some compromise.

Generally speaking, it is impossible to flatly recommend one stainless steel for any specific application. The best that can be done is to choose a grade or group of grades that seem to offer the best combination of properties and then test the steel or steels thoroughly.

In general, both the corrosion resistance and the resistance to scaling of the stainless steel increase with the higher chromium contents. In addition, substantial percentages of nickel add to corrosion resistance. Therefore, it is reasonable to assume that the alloy content of a stainless steel is a good guide to its ability to resist the attack of oxidizing corrodents, of the atmosphere and its resistance to high temperatures. The strength relationships of the stainless steels do not follow the same pattern, since strength properties depend on several other factors.

No attempt is to be made in this section to recommend any one stainless steel for a specific application. We can help in narrowing a choice to a few grades of stainless so that a potential user can have some point from which to start in making a final choice for his product.

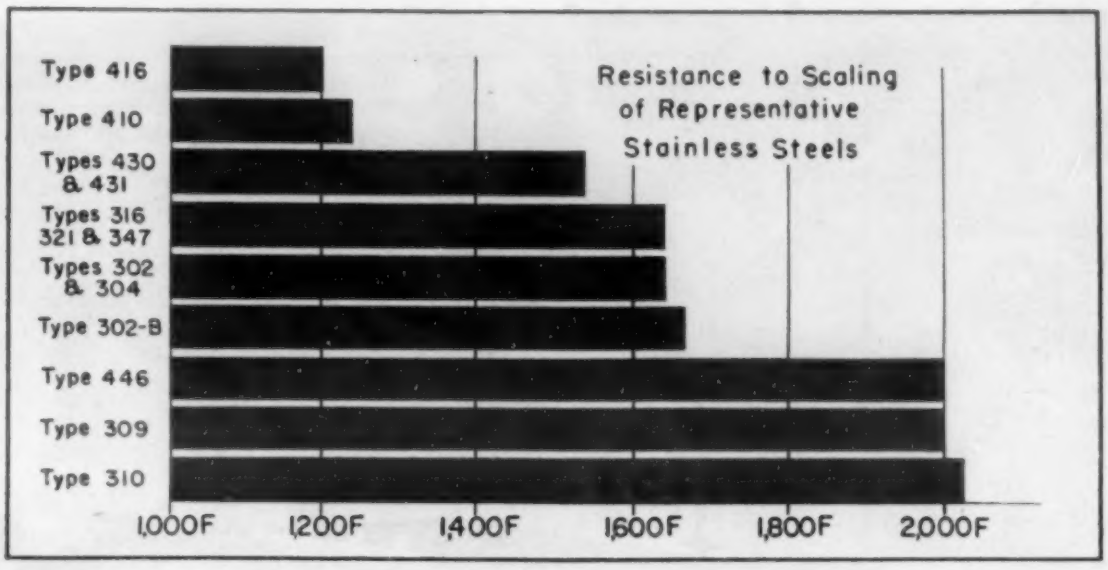
Before making a final choice, two steps should be taken:

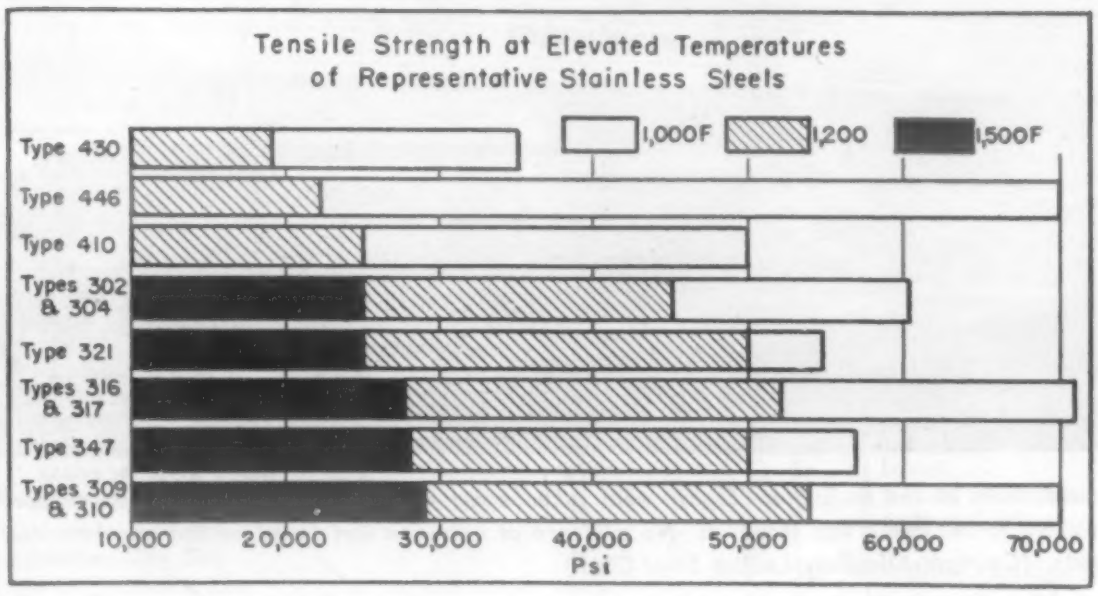
1. Seek the advice of your producer. His knowledge and experience can save considerable time and expense in many instances through past handling of problems similar in nature to yours. The producer should be told as much as can be told about the requirements of the product, conditions under which it will operate, and the methods to be used in its fabrication. All of the preceding have considerable bearing on what steel can be used.

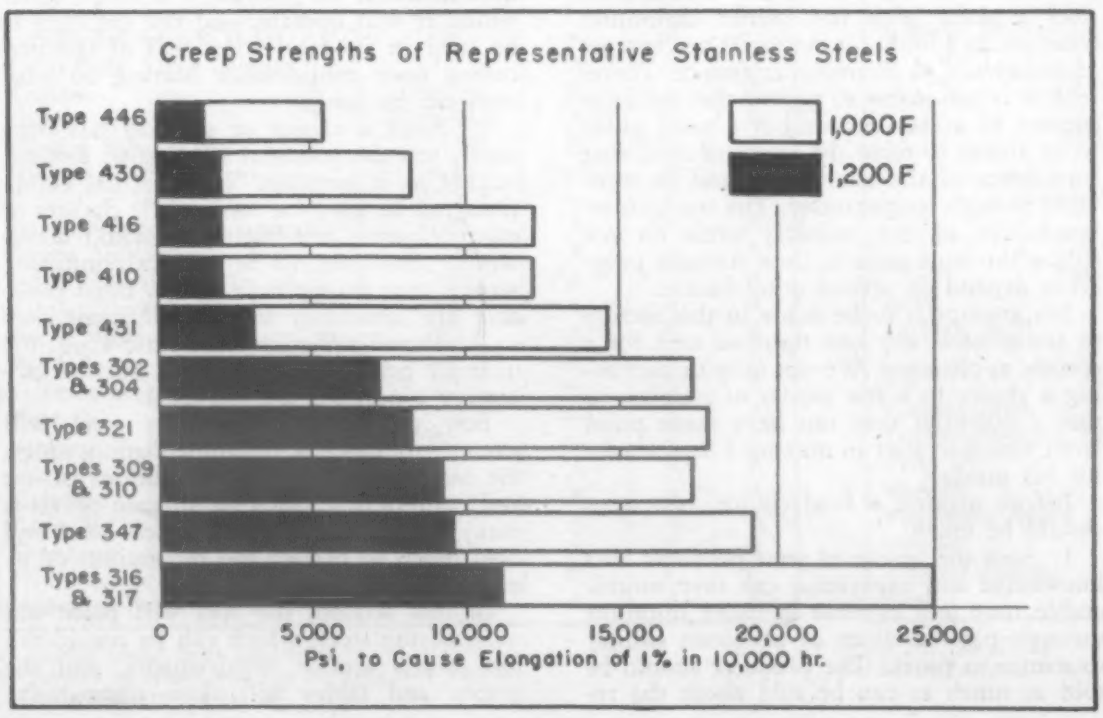
2. After a choice of stainless has been made, test the potential application as thoroughly as is possible. When actual conditions can be used for testing, the chances of misapplication are slightest. Should actual service conditions not be practical, simulated service tests might have to do. Least desirable are laboratory test data, because data so developed sometimes tell little about the ultimate behavior of the metal because laboratory conditions are too ideal.

Few producers of stainless steel will attempt to make a recommendation unless the buyer tells all of the conditions of use and manufacture. Such an attitude prevents many misapplications of stainless steel and does much to protect the reputations of its makers.

In this section, the text will point out some of the steels which can be considered for certain service requirements, and the graphs and tables will show comparative







properties of representative stainless steels. Certain choices will be restricted to special steels due to the form required for the application. In other words, the ideal steel may not be available in every form.

Corrosion Resistance

Corrosion resistance in stainless steel is hard to define and isolate. For while certain steels in this classification are highly resistant to corrosives of certain types, they offer practically no resistance to others. Too the steels resist the corrosive action of some substances if the substance is agitated. Agitation increases the corrosive action of certain other attacking mediums. Impurities in some acids have a decided effect upon the corrosive action, increasing it in some cases and reducing it in others.

Since all of the stainless steels have a minimum of 12% chromium, they are all resistant to atmospheric corrosion. Even under some industrial conditions the stainless surfaces require occasional cleaning to make certain that no foreign matter is given a chance to cling to the surface of the steel and form a point of attack. After several years of exposure to mild industrial atmospheres, Type 410 will show rust.

The austenitic (chromium-nickel) steels are highly resistant to various corrodents but if certain of these steels are subjected to heat between 750 and 1600 F, they are likely to fail through intergranular corrosion under sufficiently corrosive conditions. The same failure is possible with these steels if they have been welded and not given a subsequent anneal.

Two accompanying tables give some clue

Corrosion Resistance of Stainless Steels

(In Order of Increasing Resistance)

12% Chromium Steels
416
410, 403
405
406
420
414
17% Chromium Steels
440-C
440-B
440-A
430-F
430
431
27% Chromium Steels
446
18% Chromium-8 Nickel Steels
303
301
302
302-B
305
304
321
347
308
25% Chromium-20 Nickel Steels
309
310
Chromium-Nickel-Molybdenum Steels
316
317

to the general corrosion resistance of the ndard stainless steels.

One table lists the standard grades in er of their increasing resistance to many rosive media. As can be seen, Types 316 d 317 can be considered to have the best rosion resistance. Closely following these Types 309 and 310. The least corrosion istance, generally speaking, is to be found the 12% chromium steels, including pes 416, 410, 403 and others with the west alloy content.

The second table lists several corrosive nts and shows the relative resistance to ir attack of three grades of stainless. The ee grades shown will indicate the general havior of other standard grades of stain- s as follows:

Type 430 will suggest the corrosion re- tance of Types 440-A, 440-B, 440-C, en heat treated, and 430-F.

Type 302 indicates the resistance to cor- ion of Types 301, 303, 304, 308, 321 d 347.

And Type 316 data also can be used for pe 317.

None of the corrosion data on stainless ould be considered as conclusive until the terial has been tested under conditions near to actual service conditions as is ssible. The data shown merely help to minate those steels which will not serve der any circumstances.

gh-Temperature Oxidation esistance

Many applications of stainless steel re- ire that the material resist oxidation and aling at high temperatures. All of the ainless steels offer better resistance to this pe of destruction than do the plain carbon eels. All of the stainless steels can be used fely up to 1200 F, many of them above 400 F, and a few up to 2000 F.

The least scaling occurs in those steels having the highest chromium content, because chromium in the steels forms a highly impervious, adherent chromium-oxide film at high temperatures. Scaling is accelerated when the steel is subject to repeated heating and cooling, due to the expansion and contraction of the base metal. When heating and cooling cycles are anticipated, straight chromium steels will probably serve best, as the rate of thermal expansion is less than that of chromium-nickel stainless steels.

The best resistance to scaling under average conditions is offered by Type 446 in the straight chromium steels and Types 308, 309 and 310 in the chromium-nickel grades. All of these steels resist scaling up to 2000 F, with Type 310 offering the best all-around properties.

An accompanying chart indicates the safe working temperatures of several representative standard grades of stainless steel.

Strength at High Temperatures

In addition to resisting scaling at high temperatures, certain grades of stainless steel offer relatively high tensile strengths up to about 2000 F. Generally speaking, the chromium-nickel grades of stainless have the best high temperature strengths at all temperature levels. One exception is Type 446, which at 1000 F equals the tensile strength of the best chromium-nickel steels, namely Types 309, 310, 316 and 317. However, an increase in temperature of 200 F causes the tensile strength of Type 446 to drop tremendously.

An accompanying chart shows the relative short-time, high-temperature strength of several stainless grades.

Creep Strength

In addition to other good high temperature properties, stainless steels have good creep strengths at high temperatures. In this property, too, the chromium-nickel grades seem to excel. Type 316, for example, has a creep strength of better than 10,000 psi. at 1200 F; this compares with the best straight chromium grade, Type 431, which has a creep strength of approximately 2500 psi. at the same temperature.

Creep strength is expressed as the stress in pounds per square inch of cross-section that will cause an elongation of 1% of the original length in 10,000 hr.

Representative strengths are shown in an accompanying chart.

Strength and Hardness

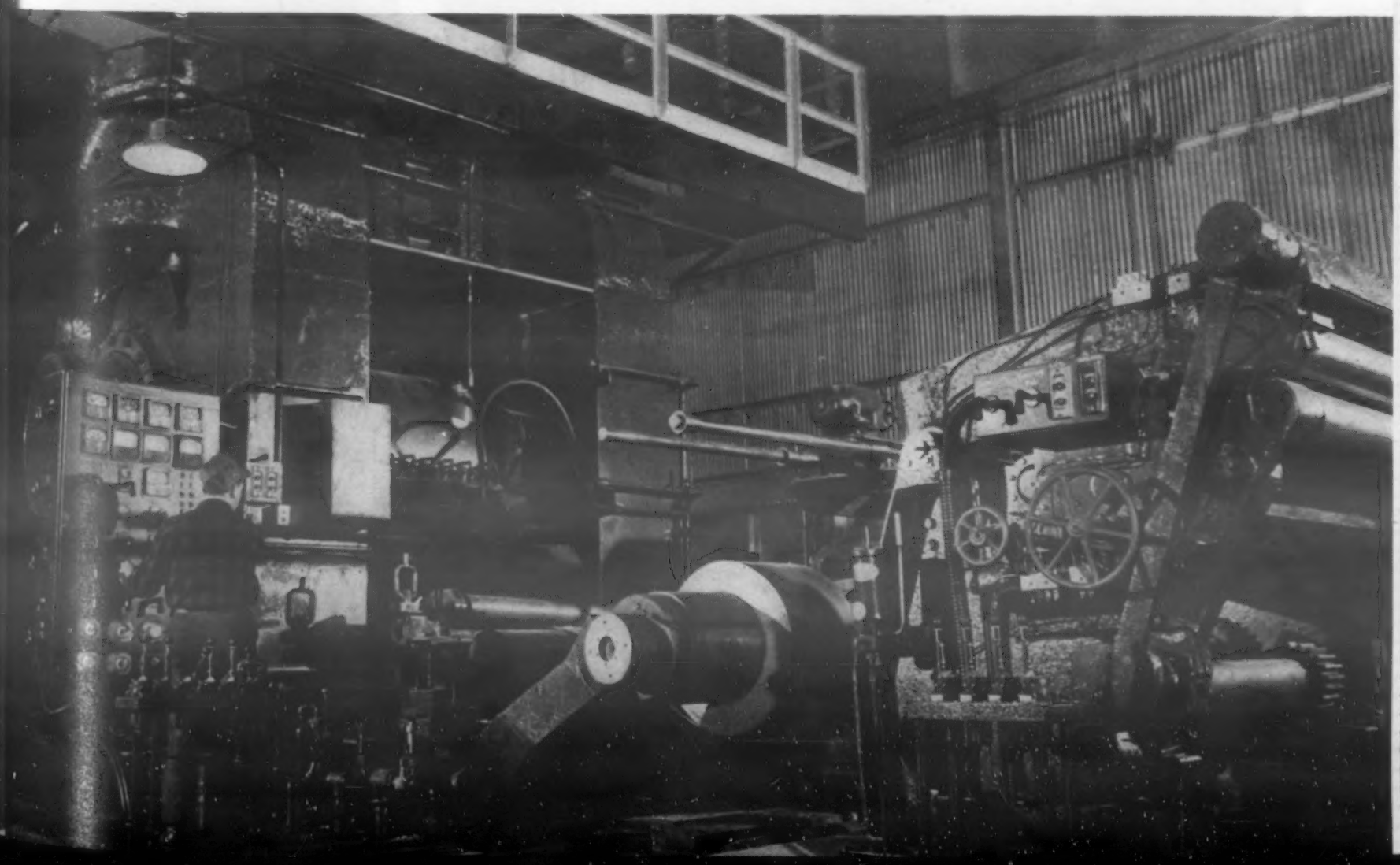
Tensile strengths of all stainless steels are good, ranging from approximately 70,000 psi. to 120,000 psi. in the annealed condition up to between 100,000 and 300,000 psi. when hardened.

There is a close relationship between tensile strength and hardness and between hardness and abrasion resistance. Therefore, where any of these properties—strength, hardness or abrasion resistance—are desired, the heat treatable straight chromium grades will be the first choice. On the other hand, if ductility is high on the list of requirements, one of the chromium-nickel grades of stainless would be best.

The greatest tensile strength and highest hardness is to be found in Type 440-C, which is often used for such parts as bearings and bushings. Tensile strength in 440-C can be raised to about 300,000 psi. through appropriate heat treatment. Room temperature strengths of most of the 18:8 stainless types range from about 100,000 to 180,000 in the cold worked condition.

In general, the highest tensile strengths are attained in the smaller cross-sections of stainless steels, and decrease as size increases.

owth in the use of stainless steels has made necessary the use of larger and faster mill equipment such as this 56-in. mill which rolls stainless at speeds up to 850 ft. per min. in Crucible Steel's new Midland, Pa. Works.



Many large shapes made from stainless are produced by spinning. One grade of stainless is particularly suited to forming by spinning. (Courtesy Carnegie-Illinois Steel Corp.)

The Effect of Processing Methods on Stainless Steel Selection

A potential user of stainless steel would be extremely foolhardy if he were to select a specific grade simply because someone else is using that grade, unless all conditions of manufacture and use are identical. The type of equipment—and its condition—used in fabricating wrought stainless steel into a finished product has a great influence upon the final choice of material.

The primary reason for the use of stainless steel, of course, is to take advantage of its corrosion resistance. For this reason, the steels of this type are not provided with the optimum in fabricating properties. However, over the years producers of stainless steels have modified the steels somewhat to give certain of them specific fabricating characteristics. Consequently, certain grades of stainless are easier to machine, others form more readily, and still others are less susceptible to sensitization in welding.

In this section, certain steels will be listed as being particularly suited to certain methods of fabrication. However, before a final choice is made there are two important steps to be taken:

1. Tell your producer to what use you intend to put the steel and exactly how you intend to process it.

This step is important, for if you have made a faulty selection, an alternative material can be suggested. Even if the choice is proper, steels within specific compositional limits vary in properties according to whether the alloy content is on the high or low side. Therefore, if the supplier is given complete information about the use and fabrication of a steel, he can make an effort to furnish a stainless grade that comes as near to your ideal as is possible.

2. Even after a selection has been established with the help of your supplier, it is not wise to run any large quantity of steel until you have fabricated a sample run on your own equipment.

A test run might seem to be a waste of time and money, but it will prove to be the cheapest insurance against future trouble.

It must be remembered that any of the usual fabricating methods can be used to fabricate any grade of stainless steel. Sometimes a specific property of a stainless steel is desired above all else. When this is true, the fabricating characteristics mean little. As an example of this condition, let's look at the metal cone used in large television viewing tubes. In searching for a metal, one condition was that the metal should have a coefficient of expansion that matched the expansional properties of glass. Stainless Grade 446 was found to be best. The cones are spun. Therefore, in this case a steel which would never be chosen for fabrication by spinning is used and is being spun. If a stainless with the best characteristics for spinning had been chosen, Type 309 would have been used.

From the preceding it can be seen that nearly any selection of stainless steel involves some compromise. Therefore, it is important that the end service requirements of the application be clearly established, grades of stainless chosen which will meet these requirements, and then a final choice made from those which offer the best fabricating characteristics for those processes employed in your plant. Where there is only one grade of stainless that meets service requirements, then the fabricating characteristics mean little as a selection factor.

ainless Steels for Cold Forming

As a group, the austenitic stainless steels er the best formability properties and, most cases, are chosen for applications olving deep drawing and spinning. How-er, for shallow forming, one of the fer-ic steels—Type 430—is useful. This steel be formed by the practices followed forming carbon steels, and drawing is the same speed.

Drawing—For all-around drawing prop-ties, Types 305 and 302 are good choices. ith Type 302, annealing between draws ll be necessary more often than with Type 5, which work hardens to a minimum.

Type 430, as indicated, is easily formed d provides a relatively low cost stainless here strength requirements are not too gh. Other stainless grades most frequently nsidered for deep drawing are Types 4, 405 and 410.

Spinning—Most of the stainless steels at have good deep drawing properties n be spun with relative ease, except that rk hardening might make necessary fre-ent anneals. To provide a satisfactory inning grade, Type 305 was developed. ype 305 work hardens much less than the her 18:8 grades, therefore deformation can be greater before annealing becomes necessary.

Type 305 is also used extensively for cold headed and upset parts, because it does not work harden rapidly.

Welding

As a group the stainless steels are relatively easy to weld. One rule of thumb which some stainless experts cite is that any stainless which can be formed readily can be welded readily. This works out to the extent that the chromium-nickel steels are the best for forming and also include the steels which would be chosen were weldability the most important fabricating requirement. Therefore, the 18:8 chromium-nickel steels are selected wherever possible for fabrication by welding.

The chromium-nickel steels, as has been discussed, are subject to heat sensitization. Therefore, a stabilized grade is required if the product is too large or unwieldy to be annealed.

Type 347 stainless, which is an 18:8 grade stabilized with columbium, is the most popular welding grade of stainless. Closely following in popularity is Type 321, which is also stabilized. In the latter steel, titanium is the stabilizing element. Of the standard unstabilized grades Type 304 stands highest, because it is less heat sensitive than the other plain 18:8 steels. It was originally developed for welding.

While not yet standard, stainless steels with carbon contents held to a minimum are now being offered for welding applications.

Machinability

All of the standard steels can be machined, although some of them require speeds considerably lower than would be used for carbon steel cutting. Where work hardening is likely to occur, deeper cuts are required, making necessary still slower speeds and more power in the machine tool.

Recognizing the fact that stainless steel fastening devices and other products on which considerable machining is required would be desirable, steel producers made available steels which could take advantage of the speed of automatic screw machines. Now there are three standard free machin-

Pails for handling chemicals and foodstuffs are being formed from stainless. In this case Type 347 is used, because welding is required. (Courtesy Armco Steel Corp.)

Processing Pointers

1. Tools, including machining tools such as lathes and millers, and "percussion machines" such as punch presses and shears and forging machines have from 150 to 200% of the capacities that would be used for fabricating the same gages or sizes of mild carbon steels. And this figure may be higher for some of the highest alloy stainless steels.

2. Machines must have plenty of rigidity and be in good mechanical condition, unless the fabricator is satisfied with low production rates and high spoilage.

3. Machines must be capable of lower speeds than sometimes are used for mild steel; their power supplies and power transmissions must be steady at low speeds.

4. Furnaces must be capable of close control.

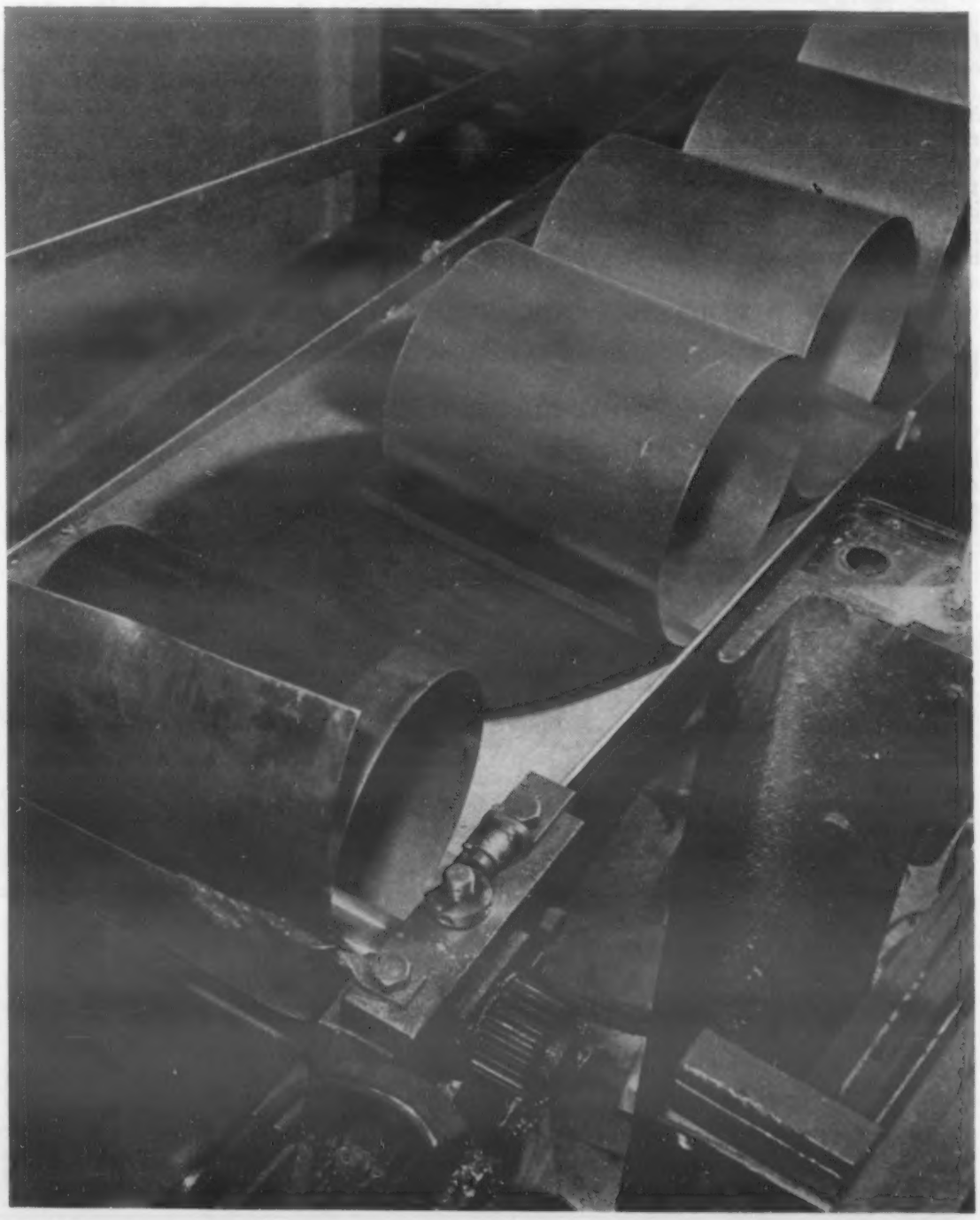
5. Capacities of heat treating equipment, of tumbling barrels, and other equipment must be ample in view of the fact that stainless steels need longer soaking periods to bring up to heat, may need more heat treatments, require longer time periods in the tumbling barrels, etc., and that the capacities of equipment to get out the same production need to be much greater for stainless than for mild steels.

6. Capacities of other equipment also must be ample in that stainless may be machined at slower speeds, take longer to polish, need extra careful and time-consuming cleaning operations.

7. Tools must be planned to reduce scrap losses, especially those from spoiled work—stainless costs too much to permit low tool costs and high spoilage ratios.

8. All tools must be thoroughly cleaned before fabricating stainless steel.

9. Use of protective coatings (plastics, paper, etc.) on finish side of stainless and on shear and brake beds can help minimize finishing costs.



Machining Speeds of Several Widely Used Stainless Steels

Grade	Surface Feet per Minute for Turning	Nearest Equivalent in Ordinary Steels (as to Machinability)
302 & 304	40/85	Copper-nickel alloys
303	85/120	SAE 3120, 3145, 4615
305	40/85	SAE Copper-nickel alloys
316 & 317	40/85	SAE Copper-nickel alloys
321 & 347	60/90	SAE Copper-nickel alloys
403 & 410	80/115	SAE 3140, 4140, 6140
414	40/80	SAE 3150, 6150
416	110/140	SAE 1030, 1120, X 1340
420	40/80	SAE 1095, 3150, 3312
430	85/115	SAE 3140, 4140, 6140
430 F	120/150	SAE 1030, 1120, X 1340
440 C	40/60	High-speed tool steel

ing stainless grades, one in each of the major stainless groups. Since they have been developed primarily for machining, these grades of stainless are produced in bar and wire forms. In the case of all three steels, phosphorus, sulfur or selenium are added to the steel's composition to make them machinable. The three steels designated as free machining have machinability ratings of about 85% that of Bessemer screw stock.

In the 18:8 grade of stainless, Type 303 is the machinable steel. Its important properties are essentially those of Type 302. In the ferritic stainless group, Type 430-F is provided for machinability. As might be imagined, the properties of Type 430-F parallel closely those of Type 430. In the hardenable stainless group is found Type 416, which comes close to duplicating the properties of Types 403 and 410.

Finishing

Problems in finishing as a selection factor in choosing a stainless steel are not too important except in the case of the free machining grades of stainless. It is difficult to obtain a good finish on the free machining grades by any of the common polishing methods. Electropolishing has a tendency to turn stainless steels of the free machining type black, and these steels resist the high polish which can be attained on many of the other grades of stainless.

It is important, however, to specify the type of finish desired when stainless sheet is ordered. For example, if the manufacture of a product involves considerable rough handling, it would be foolish to order the stainless steel with any of the three high polishes available. Likewise, where the product is not to be visible or in cases where attractiveness is not important, a cold rolled finish would be satisfactory.

Special Purpose Steels

Another important reason for checking with suppliers and giving them complete information as to uses and methods of fabricating stainless steel lies in the fact that several special purpose steels are now available from certan producers of stainless. These steels have been developed to meet specific service and fabrication requirements.

Conclusion

From much of the foregoing, it might be concluded that there still is much to be learned about stainless steels and their behavior. As with all engineering materials, that is true to a certain extent of stainless steels. The fact is that considerable information is available on stainless steels and their behavior under specific conditions. However, certain small variations in conditions can alter the results obtained when using stainless. That is why all aspects of its use and manufacture must be taken into consideration before making a final choice.

Part of the difficulty in making simple, clear-cut recommendations for stainless steel applications lies in the fact that in most cases it is decided upon when other materials fail or prove impractical. In short, stainless steel gets the tough jobs where even the requirements are hard to define.

To illustrate, one individual used nitric acid in his manufacturing process. He had a tank made of Type 304 stainless and found that it withstood the action of nitric satisfactorily. An acquaintance in the same business heard of this and decided to have a similar tank made. His failed in a short time. Investigation showed that the first man used pure nitric, while the second used less pure acid. The slight amount of impurity in the second case was sufficient to alter the corrosion resistance of the stainless steel.

Several times in this manual the suggestion has been made that before making a final selection of stainless steel—or at least when ordering—full details of the conditions of use and fabricating processes be revealed to your producer. Technical personnel of your supplier might not know all of the answers to application problems, but they certainly know enough to help you avoid the majority of pitfalls in selecting a stainless steel.

As has been pointed out, the characteristics of a steel can vary somewhat within any analysis. Thus, if a supplier knows the most desirable characteristics for your use, he can make certain that the steel you get favors your applications.

There are some instances where standard AISI stainless steels will not do the job satisfactorily. Most primary producers of stainless have a number of special grades designed to meet many of the special requirements that arise.

Once more we re-emphasize the need for complete and thorough testing of any grade of steel you may choose under conditions of manufacture and use as near to actual conditions as are possible. Handbook and catalog data are fine, but should be used only as an indication of the usefulness of a material, not as the last word on its potential performance. Nothing can tell exactly how a material will perform except actual tests under real service conditions.

After you have taken the time and effort to pick the proper stainless steel and have tested it, you can ship your product, confident that it will provide your customer with many, many years of satisfactory service.

Acknowledgment

We wish to acknowledge with appreciation the help and cooperation of the following organizations in the preparation of this manual:

Agaloy Tubing Co.
Allegheny Ludlum Steel Corp.
Alloy Metal Wire Co., Inc.
American Iron & Steel Institute
American Steel & Wire Co.
Armco Steel Corp.
Babcock & Wilcox Tube Co.
Bethlehem Steel Co.
Carnegie-Illinois Steel Corp.
Carpenter Steel Co.
Crucible Steel Co. of America
Electro Metallurgical Div., Union Carbide & Carbon Corp.
Firth Sterling Steel & Carbide Corp.
Ingersoll Steel Div., Borg-Warner Corp.
International Nickel Co., Inc.
Jessop Steel Co.
National Tube Co.
Republic Steel Corp.
Sharon Steel Corp.
Superior Steel Corp.
Timken Roller Bearing Co.
United States Steel Corp.
Westinghouse Electric Corp.

Materials Engineering File Facts

NUMBER 192
May, 1950

MATERIALS DATA SHEET

Wrought Coppers and Plain Brasses

Typical Properties and Uses

Type	Electrolytic Tough Pitch Copper	Deoxidized Copper	Gilding, 95%	Commercial Bronze, 90%	Red Brass, 85%
COMPOSITION, % (Excluding Impurities)	Cu, 99.90 min. Oxy. about 0.04	Cu, 99.90 min. P, 0.015-0.040	Cu, 94.0-96.0 Zn, remainder	Cu, 89.0-91.0 Zn, remainder	Cu, 84.0-86.0 Zn, remainder
PHYSICAL PROPERTIES					
Density, Lb./Cu. In.	0.321-0.323	0.323	0.320	0.318	0.316
Melting Range, F	1949-1981	1981	1920-1950	1870-1910	1810-1880
Ther. Cond., Btu./Hr./Sq. Ft./Ft./F, @ 68 F	226	196	135	109	92
Coeff. of Exp. per F (68-572 F)	9.8×10^{-6}	9.8×10^{-6}	10.0×10^{-6}	10.2×10^{-6}	10.4×10^{-6}
Spec. Ht., Btu./Lb./F, @ 68 F	0.092	0.092	0.09	0.09	0.09
Elect. Res., Microhm-Cm, @ 68 F (Annealed)	1.71	2.03	3.1	3.9	4.7
MECHANICAL PROPERTIES					
Mod. of Elasticity in Tension, Psi.	17.0×10^6	17.0×10^6	17.0×10^6	17.0×10^6	17.0×10^6
Tensile Str., 1000 Psi.:[1]					
Annealed[3]	32.0, 35.0	32.0	34.0	37.0, 40.0	39.0, 41.0
Half Hard	42.0	42.0	48.0	45.0, 60.0	57.0, 72.0
Hard	50.0, 55.0	50.0	56.0	54.0, 74.0	70.0, 88.0
Spring	55.0, 66.0	55.0	61.0	72.0, 90.0	84.0, 105.0
Yield Str., 1000 Psi.:[2]					
Annealed[3]	10.0	10.0	10.0	10.0	10.0
Half Hard	36.0	36.0	40.0	45.0	49.0
Hard	45.0	45.0	50.0	54.0	57.0
Spring	50.0	50.0	55.0	62.0	63.0
Elongation in 2 In., %:					
Annealed[3]	45, 35	45	45	45, 50	48, 48
Half Hard	14	25	12	11, 6	12, 8
Hard	6, 1.5	8	5	5, 4	5, 6
Spring	4, 1.5	—	4	3, 3	3
Hardness, Rockwell:					
Annealed[3]	40F	40F	46F	53F	56F
Half Hard	40B	40B	52B	58B	65B
Hard	50B	50B	64B	70B	77B
Spring	60B	60B	70B	78B	86B
Shear Str., 1000 Psi.:					
Annealed[3]	22.0, 24.0	22.0	26.0	28.0, 30.0	31.0, 31.0
Half Hard	26.0	26.0	34.0	35.0, 37.0	37.0, 43.0
Hard	28.0, 29.0	28.0	37.0	38.0, 42.0	42.0, 48.0
Spring	29.0, 33.0	29.0	39.0	42.0	46.0, 54.0
Endurance Str., 1000 Psi.[1] (100 million cycles):					
Annealed[3]	11.0	—	—	10.0	10.5
Half Hard	12.0	14.0	—	15.5, 19.0	18.0, 27.0
Hard	13.0	19.0	—	17.0, 21.0	21.0, 29.0
Spring	11.0	18.5	—	19.0, 23.0	24.0, 27.0
FABRICATING PROPERTIES					
Capacity for Being Cold Worked	Excellent	Excellent	Excellent	Excellent	Excellent
Capacity for Being Hot Worked	Excellent	Excellent	Good	Good	Good
Hot Working Temp., F	1400-1600	1400-1600	1400-1600	1400-1600	1450-1650
Annealing Temp., F	700-1200	700-1200	800-1450	800-1450	800-1350
Machinability (Free-Cutting Brass = 100)	20	20	20	20	30
Joining Characteristics:					
Soft Soldering	Excellent	Excellent	Excellent	Excellent	Excellent
Silver Alloy Brazing	Good	Excellent	Excellent	Excellent	Excellent
Oxyacetylene Welding	Poor	Fair	Fair	Good	Good
Carbon Arc Welding	Fair	Good	Good	Good	Good
Resistance Welding	Poor	Poor	Poor	Poor	Poor
Common Fabrication Processes	Blanking, coining, drawing, etching, piercing and punching, shearing, spinning, squeezing and swaging, stamping. Coppersmithing, heading and upsetting, hot forging and pressing, impact extrusion, roll threading and knurling.	Forming and bending, coppersmithing, hot forging and pressing.	Forming and bending.	Forming and bending, heading and upsetting, hot forging and pressing, roll threading and knurling.	Forming and bending, heading and upsetting, roll threading and knurling.
CORROSION RESISTANCE	Generally good resistance to industrial, rural and marine atmospheres; gasolines; fuel oils; lacquers. Generally poor resistance to ammonia, ferric and ammonium compounds, and cyanides. Good resistance to weak acids and bases; some resistance to strong acids and bases.		Highly resist. to dezincification or stress-corr. cracking.		Best gen. corr. res. among plain brasses.
AVAILABLE FORMS	Flat products, rod, wire, tube pipe, shapes.	Tube, pipe, rod, rolled strip.	Rolled strip.	Rolled strip, sheet, plate, rod, wire, tube.	Rolled strip, sheet, wire, tube, pipe.
TYPICAL USES	Architectural trim; automobile radiators; electrical contacts, conductors and switches; ball floats; rivets; chemical process equipment.	Plumbing and gas lines; heat exchanger tubes, air, water, gasoline and oil lines; rotating bands.	Coins; bullet jackets; fuse caps; primers; jewelry; base for gold plate or vitreous enamel.	Grillwork; cosmetic compacts; marine hardware; primer caps; costume jewelry; vitreous enamel base.	Weatherstrip; electrical sockets; fasteners; heat exchanger tubes; flexible hose; plumbing lines; jewelry.

(Continued on page 101)

Materials Engineering File Facts

NUMBER 192 (Continued)

WROUGHT COPPERS AND PLAIN BRASSES

Type	Low Brass, 80%	Cartridge Brass, 70%	Yellow Brass	Muntz Metal
COMPOSITION, % (Excluding Impurities)	Cu, 78.5-81.5 Zn, remainder	Cu, 68.5-71.5 Zn, remainder	Cu, 63.0-68.5 Zn, remainder	Cu, 59.0-63.0 Zn, remainder
PHYSICAL PROPERTIES				
Density, Lb./Cu. In.	0.313	0.308	0.306	0.303
Melting Range, F	1770-1830	1680-1750	1660-1710	1650-1660
Ther. Cond., Btu./Hr./Sq. Ft./Ft./F, @ 68 F	81	70	67	71
Coeff. of Exp. per F (68-572 F)	10.6×10^{-6}	11.1×10^{-6}	11.3×10^{-6}	11.6×10^{-6}
Spec. Ht., Btu./Lb./F, @ 68 F	0.09	0.09	0.09	0.09
Elect. Res., Microhm-Cm, @ 68 F (Annealed)	5.4	6.2	6.4	6.2
MECHANICAL PROPERTIES				
Mod. of Elasticity in Tension, Psi.	16.0×10^6	16.0×10^6	15.0×10^6	15.0×10^6
Tensile Str., 1000 Psi.:[1]				
Annealed[3]	42.0, 44.0	44.0, 48.0	46.0, 50.0	54.0
Half Hard	61.0, 82.0	62.0	61.0, 88.0	70.0
Hard	74.0, 107.0	76.0	74.0, 110.0	—
Spring	91.0, 125.0	94.0, 130.0	91.0, 128.0	—
Yield Str., 1000 Psi.:[2]				
Annealed[3]	12.0	11.0	14.0	21.0
Half Hard	50.0	52.0	50.0	50.0
Hard	59.0	63.0	60.0	—
Spring	65.0	65.0	62.0	—
Elongation in 2 In., %:				
Annealed[3]	52, 55	66, 64	65, 60	45
Half Hard	18, 8	23	23, 15	10
Hard	7, 5	8	8, 8	—
Spring	3, 3	3, 3	3, 3	—
Hardness, Rockwell:				
Annealed[3]	57F	54F	58F	80F
Half Hard	70B	70B	70B	75B
Hard	82B	82B	80B	—
Spring	91B	91B	90B	—
Shear Str., 1000 Psi.:[1]				
Annealed[3]	32.0, 32.0	32.0, 34.0	32.0, 34.0	40.0
Half Hard	39.0, 47.0	40.0	40.0	44.0
Hard	43.0, 53.0	44.0	43.0, 55.0	—
Spring	48.0, 60.0	48.0, 60.0	47.0, 60.0	—
Endurance Str., 1000 Psi.[1] (100 million cycles):				
Annealed[3]	14.0	10.0	13.5	—
Half Hard	20.0	18.5	19.0	—
Hard	22.0, 23.0	21.0	19.0, 20.0	—
Spring	22.5, 26.5	23.0, 23.0	19.0, 22.5	—
FABRICATING PROPERTIES				
Capacity for Being Cold Worked	Excellent	Excellent	Excellent	Fair
Capacity for Being Hot Worked	Fair	Fair	Poor	Excellent
Hot Working Temp., F	1500-1650	1350-1550	—	1150-1450
Annealing Temp., F	800-1300	800-1400	800-1300	800-1100
Machinability (Free-Cutting Brass = 100)	30	30	30	40
Joining Characteristics:				
Soft Soldering	Excellent	Excellent	Excellent	Excellent
Silver Alloy Brazing	Good	Good	Good	Good
Oxyacetylene Welding	Good	Good	Good	Good
Carbon Arc Welding	Fair	Fair	Fair	Fair
Resistance Welding	Poor	Fair	Fair	Fair
Common Fabrication Processes	Blanking, drawing, etching, forming and bending, heading and upsetting, piercing and punching, shearing, spinning, squeezing and swaging, stamping. Roll threading and knurling.		Roll threading and knurling.	Blanking, forming and bending, hot forging and pressing, hot heading and upsetting, shearing.
CORROSION RESISTANCE	Generally good resistance to industrial, rural and marine atmospheres; gasolines; fuel oils; lacquers. Generally poor resistance to ammonia, ferric and ammonium compounds, and cyanides. Susceptible to dezincification and stress-corrosion cracking. Good resistance to weak bases; some resistance to strong bases and weak acids; poor resistance to strong acids.	Some resistance to weak acids and bases; poor resistance to strong acids and bases. Good resistance to sulfides. Poor resistance to soft and high salinity water.		
AVAILABLE FORMS	Wire, rolled strip and flat wire.	Rolled strip and flat wire, drawn flat wire, rolled bar, sheet, rod, wire, tube.	Rolled strip and flat wire, drawn flat wire, sheet, plate, rod, wire.	Rolled strip and bar sheet, plate, rod, tube.
TYPICAL USES	Ornamental metal work; battery caps; musical instruments; clock dials; pump lines.	Automotive radiator cores and tanks; lamp fixtures; fasteners; springs; ammunition components.	Grillwork; reflectors; lamp fixtures; fasteners; stencils; plumbing accessories; springs.	Architectural trimmings; large nuts and bolts; condenser plates; hot forgings; valve stems.

NOTES:

[1] *Values given for flat products; where two values are given, second is for wire.*

[2] *Yield strength for 0.5% extension under load.*

[3] *These annealed properties represent those of softest tempers usually used commercially. Annealed tempers must be specified by grain size.*

Prepared with the assistance of the Copper & Brass Research Assn.

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New Materials and Equipment

Materials

ctrical Grade Plastic

new resin, claimed to be the easiest-cessing electrical grade yet developed, been announced by the *Naugatuck mical Div.* of *U. S. Rubber Co.*, Paines-e, Ohio. Known as Marvinol VR-20, new resin is the second of a projected es intended to meet different specialized uirements.

lasticized with dioctylphthalate, the n compound has the following physical perties: Shore "A" hardness—78; ulti-e tensile strength—2600 psi.; ultimate ngation—360%; 100% modulus—1300 ; and tear strength—430 lb. per in. lasticized with tricresyl phosphate, the npound has: Shore "A" hardness—85; mate tensile strength—2950 psi.; ulti-e elongation—340%; 100% modulus 025 psi.; and tear strength—590 lb. in.

he new resin is expected to almost pletely eliminate the need for copoly- processing-aid resins in connection h calendering. In addition, it permits ering Banbury and calender tempera-s 10 to 15 deg. below previous practice. xtrusions of Marvinol VR-20 com-nds are claimed to have shown good s at temperatures 10 to 20 deg. below se used with most proprietary resins, its gloss retention appears good even h a high percentage of filler. The resin be handled on conventional vinyl-cessing equipment.

minum Casting Alloy

new aluminum casting alloy, known Almag 35 and possessing high as-cast ngth, is being marketed by *William Jobbins, Inc.*, Aurora, Ill. The material tains 6.5 to 7.5% magnesium, together with small amounts of other alloying elements.

Typical as-cast properties of 40,000 psi. ultimate tensile strength, 21,000 psi. yield strength, 13% elongation and 70 Brinell hardness are claimed for this new alloy. It is claimed to have four times the machinability of No. 108 aluminum alloy, and the highest corrosion resistance of any aluminum alloy. As a result, Almag 35 is said to make available castings with properties ordinarily obtained only after expensive heat treatments.

(*Ed. note*—The properties and applications of Almag 35 will be described in more detail in a feature article to appear shortly in MATERIALS & METHODS.)

Electrically Conductive Glass

Electrically conductive glass panels are now being produced commercially by *Corning Glass Works*, Corning, N. Y. The new material is Pyrex borosilicate glass having a metallic oxide coating about 1.6×10^{-5} in. thick. The transparent skin is a semiconductor of electricity, possessing enough resistance to heat the glass up to 660 F. Electrically conductive glass is currently being used for many heating applications, such as de-icing windshields, warming chicken incubators, and drying textile yarn.

The electrically conductive surface is harder than the glass base and is extremely resistant to chemical attack, provided reducing agents are not present. The extreme thinness of the coating makes it necessary, however, to avoid scratching the surface with an abrasive.

The conducting film can be applied to the glass in a uniform or non-uniform thickness, as the application requires. Electrical contact is made through silver bands permanently bonded to opposite edges. The glass can be made with varying degrees of resistivity from 6 ohms to several thousand ohms per square area.

At the present time, the E-C glass is available only in a limited number of sizes of flat panels, though additional forms are being developed. (Further information on the development, applications and technical characteristics of electrically conductive glass can be found in MATERIALS & METHODS, Aug. 1949, p. 70.)

CONTENTS

Parts & Forms

Large Plastic Tubing

Thermosetting plastic tubing up to 26-in. O.D., 25¾-in. I.D. and 96-in. length is now available from *Synthane Corp.*, Oaks,

New Materials and Equipment
(CONTINUED)

Pa. Large plastic tubing is of special interest to transformer manufacturers and to the textile industry. Maximum diameter previously available was 23 in.

Free-Machining Stainless Tube

A free-machining welded stainless tube, Type 303, has been developed by the *Carpenter Steel Co., Alloy Tube Div.*, Union, N. J., for products requiring corrosion resistance combined with good machinability.

The Type 303 tube is recommended for parts which must be fabricated by threading, turning, reaming, drilling, etc., and for intricate or difficult-to-machine parts where smooth surfaces are required. Typical applications are all types of screw machine products, bearings and bushings, instrument parts, bottle filling nozzles, special valve parts, wax molds, soda fountain pumps, gasoline stove valve and parts, and parts for fishing reels.

Actual machining tests have shown that the tube is as machinable as Type 303 bar stock, and can be handled in automatic screw machines at about 70% of the speed of SAE 1120. In addition to good machinability and corrosion resistance, the steel has non-galling properties that ease disassembly of parts and help avoid scratching or galling in moving parts.

The stainless tube is available in rounds or shapes from ¼- to 4½-in. O.D. and in all standard wall thicknesses. These welded tube forms are claimed to be less expensive than other Type 303 tubing heretofore available.

The steel analysis is 0.08 maximum carbon, 17 to 19 chromium, 8 to 10 nickel, and 0.07% minimum selenium. Since this steel work-hardens rapidly, cold working applications such as bending, flaring or rolling into tube sheets are not recommended.

Welded Steel Tubing

Resistance-welded steel tubing is now available from *Wallingford Steel Co.*, Wallingford, Conn., in stainless, carbon, alloy, cold rolled or hot rolled stock. The tubing is being manufactured in ½- to 3-in. O.D., 24 to 11 gage, cut in lengths of 4 ft. and up.

Heat Treating & Heating

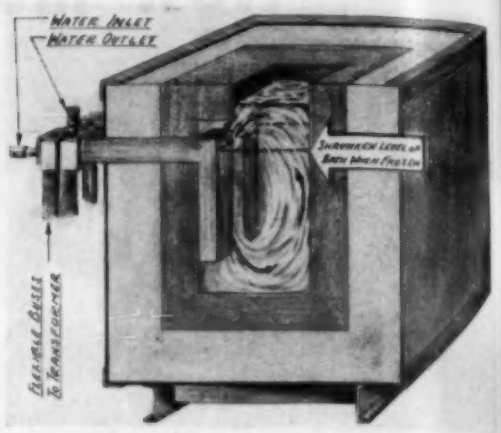
Salt Bath Furnace

An Ajax Hultgren salt bath furnace, equipped with newly patented submerged electrodes, has been announced by *Ajax Electric Co., Inc.*, Frankford Ave. at Delaware Ave., Philadelphia 23, Pa. The furnace is recommended for use with salt baths operating at temperatures from 1700 to 2400 F, as well as for exceptionally deep baths.

Instead of the electrodes entering from the top of the bath, as in the standard design, they enter through the back wall of the furnace just below the surface of the bath. They are so positioned that, should the bath freeze, the salt will shrink sufficiently to expose the electrodes for restarting.

Specifically, submerged electrodes are recommended for deep baths for heat treating long work from 1100 F upward; for the high-heat unit used in hardening high-speed steel tools at 2200 to 2375 F; for high carbon-high chromium dies at 1850 F; and for all operations carried out in neutral salts above 1700 F, such as hardening carbon and alloy steel, annealing and hardening stainless steel, heating for forging and brazing.

Primary advantage of using submerged electrodes for high temperature work is the longer electrode life resulting from protection against oxidation. In addition, the exposed bath surface is reduced to a minimum, which, in turn, is claimed to reduce power consumption as much as 30% on high temperature units. The restricted bath surface also reduces sludge formation.



Should the bath freeze, the salt will shrink enough to expose the electrodes of the new Ajax Hultgren furnace for restarting.

Since submerged electrodes are at present restricted to use with ceramic pots, this design is not recommended for cyanide hardening, carburizing, descaling, cleaning, desanding or use with nitrate salts; the much cheaper and long-lived welded steel pots are said to give best service for these applications.

Refractory

A new lightweight refractory for furnace walls and door linings has been developed by *Harbison-Walker Refractories Co.*, 1800 Farmers Bank Bldg., Pittsburgh, Pa.

Weighing only 56 lb. per cu. ft., H-W 56 Lightweight Castable has a thermal conductivity 65% less than that of high-duty fireclay brick. It is said to have high strength and good volume characteristics throughout its working temperature range, which extends up to 2000 F.

Induction Heater

The LI-10 Induction Heating Unit, having a capacity of 10 kw., has been announced by the *High Frequency Heating Div., Lindberg Engineering Co.*, 2444 W. Hubbard St., Chicago 12, Ill.

Single- and two-station models are available with high and low impedance terminals at each station. Input is 230 or 460 v., 3 phase, 60 cycles. All filament voltages are automatically regulated by constant voltage type transformers.

The oscillator tube is air-cooled, and a make-up, temperature-controlled water system cools tank components and work coils.

The Case of the Complete Coverage

The McKay Stainless Electrode line completely covers your requirements for electrodes to weld all types of stainless-steels including the extra low carbon, chrome-nickel steels; the high nickel-chrome, heat-resisting alloys; and the new steels developed for the high-temperature alloys used in super-chargers, heat turbines, jet engines and rockets.

McKay Stainless Electrodes—in Lime, DC Titania and AC-DC coatings—are especially designed to deposit weld-metal similar in chemical analysis and physical properties to the stainless-steels welded with them.

McKay Lime Coated Electrodes are characterized by large, hot arc puddles. The slag, though fluid when molten, freezes quickly and so makes it easy to weld in vertical positions without having the weld-metal fall away from or into the weld.

McKay DC-Titania Coated Electrodes have small, restricted arc puddles and slag that moves quickly away from the arc . . . with the result that there is no slag interference with the arc action and weld beads are smooth and finished. Low spatter loss and easy slag removal make these electrodes ideal where ease of welding and good weld appearance are important.

McKay AC-DC Coated Electrodes are recommended for their arc stability, low spatter loss and ease of operation in vertical, overhead and other positions. They strike and restrike easily with little or no tendency to stick or freeze. The slag produced is easy to control and does not interfere with the arc action. Weld beads are smooth and uniform.

Your inquiries are invited on standard and "special" McKay Stainless Electrodes. Immediate delivery on standard grades.

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McKay Welding Engineers will gladly advise you, without obligation on the selection of electrodes and the most efficient welding procedure to obtain best results when welding stainless-steels.

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Researched, Developed and Manufactured to fill Industry's Requirements for Dependable Electrodes

New Materials and Equipment
(CONTINUED)

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A number of new features have been incorporated in this new Lindberg induction heating unit.

are: greatly reduced water consumption, elimination of harmful condensation, less sensitivity to water pressure, and unimpaired operation in hard water areas.

●

Protective Coatings

Temporary Protective Coatings

Two temporary protective coatings have been developed by *Fidelity Chemical Products Corp.*, 470 Frelinghuysen Ave., Newark 5, N. J. One is a strippable coating, SP-14, for enameled, lacquered and plastic surfaces; the other is a hot melt coating, Dip-Pak No. 532, for metal parts such as tools, gears and machined components. Both coatings offer temporary protection during processing, storage and shipping.

Fidelity SP-14 is a cream-colored liquid, with good stability, which will not affect color or any type of finish to which it is applied. When dry, the film is claimed to be non-inflammable, elastic, abrasion resistant, and to adhere strongly to the surface to which it is applied. Yet the film can be removed by a steady pull when desired.

Best results with SP-14 are obtained if the parts, after spraying, are passed through a drying oven at 140 to 150 F for about 15 min. Oven drying is not necessary if the film is allowed to air-dry for about 1 hr. and to remain on the part at least 48 hr. before peeling.

Fidelity Dip-Pak No. 532 is furnished in briquette form and when melted and applied, provides a transparent, abrasion-resistant, moisture-resistant coating. This coating sets up almost immediately as it contacts air, and can be removed by slitting and peeling off. Since the material consists entirely of solids, it can be used repeatedly by remelting. This coating is claimed to resist corrosion under all climatic and weathering conditions.

Water-Resistant Coating

The *Dampney Co. of America,* Hyde Park, Boston 36, Mass., has announced a new vinyl resin formulation for pretreatment of metal scheduled for underwater service. This material, designated Dampney Metal Primer, serves to inhibit corrosion temporarily prior to finish coating and to provide good bonding for the surfacing material.

The primer is readily applied by either brush or spray to any type of clean metal. Only one coat is required and a gallon is said to protect 800 to 1000 sq. ft. of surface. The film dries rapidly so that no more than ½ hr. need elapse before finish coating. Apexior No. 3 is the finish coating recommended in connection with this primer for metals to be protected during water-submerged service.

Rolled Gold Plate

Rolled Gold Plate, with a gold layer more than ten times as thick as average gold electroplate and with a mirror-like finish, is now being produced by the *Rolled Plate Div.* of *American Silver Co., Inc.*, 36-07 Prince St., Flushing, N. Y., at an estimated cost of 3c per sq. in.

The Rolled Gold Plate, protected by a thin plastic coating called Filmkote, is available on a variety of metals (including brass, copper, nickel, nickel silver, beryllium copper, etc.) in thicknesses down to 0.005 in. and in strip from ¼ to 4½ in. wide. This product is the result of American Silver Co.'s development of the Inter-Weld Process last year (MATERIALS & METHODS, Oct. 1949, p. 102). The process makes possible production of rolled gold plate which competes in cost with electroplate, but is claimed to out-wear gold electroplate.

Multi-Purpose Lacquer

A new lacquer which is said to provide an effective finish for all types of wood and metal products has been developed by *United Lacquer Manufacturing Corp.*, 1001 W. Elizabeth Ave., Linden, N. J. Named Base C 5015, this versatile material can be applied by spraying or dipping and is available in clear or colors, in either a full gloss, semi-gloss or flat finish.

Plastic Coatings

The first two of a series of KEL-F plastic dispersions for protective coatings are now available from the *M. W. Kellogg Co., Chemical Manufacturing Div.*, P. O. Box 469, Jersey City 3, N. J. Both grades are non-aqueous dispersions, with N-I containing approximately 20% of dispersed KEL-F (trifluorochloroethylene) plastic and NW-25 containing about 27% solids. These dispersions permit application of KEL-F to materials and equipment not adaptable to processing by conventional plastic molding.

The KEL-F N-I dispersion can be used to directly coat clean metallic surfaces, stoneware, glass, etc.; particular care should be taken to round off sharp edges. The other dispersion, KEL-F, NW-25, is believed to be suitable for coating textiles, paper, wood and other heat-destructible materials.

General procedure in applying these dispersions is to build up a layer on the surface by spray, brush or dip methods, then dry out the solvent and fuse to a continuous film. Usually, satisfactory films are obtained when KEL-F NI is heated 1 to 3 min. at 625 to 680 F and KEL-F NW-25 for 10 to 30 min. at 435 to 465 F. The properties of KEL-F films produced by coating from KEL-F NI followed by fusion have been found comparable to those of previously reported KEL-F protective coatings applied by pressing, extrusion or compression molding.

These dispersions are being offered for industrial study at this time so that they can be evaluated under actual commercial conditions.

the New Arithmetic in Steel

Make each ton of steel go farther. Get four products in place of three from the same amount of steel. Let the high physical properties of N-A-X HIGH-TENSILE take the place of mass in your product design to boost production per ton as much as 33%. This new efficiency in the use of steel is part of industry's constant search for better materials.

With N-A-X HIGH-TENSILE steel you are assured of high resistance to distortion, impact fatigue and corrosion. Yet you are also assured of excellent cold formability and weldability.

Thus you can redesign many steel products with sections 25% thinner—to save weight, save steel. And further savings in fabricating and finishing pay the way to use of this better, more efficient material.

Let us talk over with you the application of N-A-X HIGH-TENSILE to your product. We believe we can show you how to increase production per ton as much as 33%.

N-A-X HIGH-TENSILE STEEL

GOES FARTHER

Builds More Products per Ton

MAKE A TON OF SHEET STEEL GO FARTHER
Specify—
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HIGH-TENSILE STEEL

GREAT LAKES STEEL CORPORATION

N-A-X ALLOY DIVISION • ECORSE, DETROIT 29, MICHIGAN • UNIT OF NATIONAL STEEL CORPORATION

New Materials and Equipment

Corrosion Resistant Coatings

A new series of plastic-base coatings, known as the V-200 series, has been developed by *Specialty Coatings Laboratory*, 1721 N. Water St., Milwaukee 2, Wis., for corrosion resistance applications.

The coatings are recommended for use over metal, wood or concrete wherever a simplified coating system is required to withstand the corrosive vapors present in chemical or processing plants. They can be applied by spray, brush or dip, and can be quickly air-dried or baked to produce flexible, abrasion resistant coatings having good adherence even to polished metal.

These coatings are claimed to have long life when subjected to salt atmospheres, alcohols, soaps, fruit juices, acids, alkali, petroleum products, or related corrosives.

Protective Coating

A corrosion- and oxidation-resistant coating for metals and other surfaces has been announced by *End-O-Rust, Inc.*, 1900 Euclid Ave., Cleveland, Ohio.

Called End-O-Rust, the coating will air dry in 2 to 3 hr., force dry within 30 min., and can be infra-red baked in 3 to 5 min. No special surface protection is required.

The new coating is claimed to have good resistance to salt-spray, caustic soda, ammonia, and sulfuric, nitric, acetic and hydrochloric acids. The hard gloss finish is recommended especially for exposure to dampness, high humidity and salt air.

●

Cleaning & Finishing

Plating Cylinder

A Mercil Type Merlon ribless cylinder, measuring 14 by 30 in., has been developed by *Hanson-Van Winkle-Munning Co.*, Matawan, N. J., for use with all commonly employed plating solutions. This cylinder is claimed to hold 15% more work than the same overall size of any conventional plating cylinders.

The cylinder is of hexagonal shape, the body being made up of five covers. No ribs, tie rods or tie rod tubing are used. The cylinder employs flexible dangler, hair pin

New Materials and Equipment

dangler or disk-type contacts. The simplified construction is claimed to reduce maintenance costs.

Also, where flexible dangler contact is used, there is no chance of build-up of deposit on parts of the cylinder, as the only place in the cylinder where current is available is at the end of the contact.

Grinding Wheel

A reinforced hub wheel, designed for use on right angle portable grinders and disk sanders primarily in weld grinding and foundry operations, is being produced by *Norton Co.*, 1 New Bond St., Worcester, Mass.

High strength, safety and durability, in addition to a fast cutting rate, are claimed for the new abrasive wheel.

Portable Paint Sprayer

A portable paint sprayer, which is claimed to deliver low-pressure, high-volume spray without mist or paint fog, is being manufactured by the *Genwind Corp. of America*, 701 Seneca St., Buffalo 10, N. Y.

The 10½-lb. Genwind sprayer can be used for spraying paint, lacquer, adhesives

The portable Genwind sprayer can be used for coating or cleaning metals.

and cleaning solutions. It gives immediate pressure up to 40 psi. without pump or compression tank, by means of a series of fans. Trigger control on the gun eliminates nozzle adjustment during operation.

We'll Gladly Accept your Order...

Subject to a Great Big IF

Engineering knowledge, tooling, and production know-how, coupled with the most modern equipment available, are what it takes to produce quality parts made from metal powders—and Moraine has all these in full measure. Naturally, we seek your order, provided we are convinced that the metal powder process will work to *your* advantage—in lowered costs and better performance.

Ask Moraine whether parts you are using can advantageously be produced by powder metallurgy. We'll gladly accept your order—

- IF the shape of the part permits good die fill and correct density . . .
- IF its required physical properties and tolerances can be obtained by our normal production methods . . . *and*
- IF it is to be made in quantities sufficient to justify tooling costs, set-up, and equipment loading.

Those are the three big IF's . . . and here's another just as important: IF we accept your order, you can be sure, in advance of delivery, that Moraine parts will justify your interest and may reduce your manufacturing costs.

MORAINE PRODUCTS
DIVISION OF GENERAL MOTORS
DAYTON, OHIO

New Materials and Equipment

Silica-Free Abrasive

A non-metallic, silica-free abrasive [is] being marketed by *American Wheelabrator & Equipment Corp.*, Mishawaka, Ind., [to] replace silica sand for blast cleaning [and] finishing operations.

The new abrasive, called Black Beauty, is sharp and fast cutting, retaining its abrading qualities even when reduced to fine material. It is claimed to wear 2 to [3] times longer than sand; to be less damaging to equipment; to be noncorrosive; and to flow freely. Absence of silica removes an important occupational hazard.

The Black Beauty abrasive is supplied in a variety of sizes graded for any type of work or finish desired.

Paint Spraying Masks

Electroformed copper masks for use in precision spraying of paints and lacquers on metals, plastics and rubber are being manufactured by *Vetrod Corp.*, 17 Williams Ave., Brooklyn 7, N. Y.

The copper shell fits over the object to be processed and designated areas are cut out of the shell to allow paint to pass through. Repeated spraying in these areas can be done without fogging or other defects. Multicolor work can be done in progressive steps by inexperienced help.

Tumbling Barrel Lining

A new plastic material which can be used in making tumbling barrels or as a lining for tumbling barrels of other construction has been announced by *Lupomatic Industries, Inc.*, 4510 Bullard Ave., New York 66.

For this application, the new plastic composition is claimed to be structurally as strong as steel and to have 40 times the abrasion resistance of wood. Called Tumb-L-Dur, this material is suitable for either the wet or dry process of tumbling. It offers particular advantage in wet tumbling, as it does not warp and there is no need, therefore, to keep the barrel under water when not in use.

Although the initial cost of Tumb-L-Dur is greater than its wooden counterpart, considerable savings are claimed as a result of uninterrupted production and elimination of replacement costs. The plastic is being used for fabricating barrels and liners, and a completely molded barrel is expected to be available soon.

New Materials and Equipment

Paint Spray Gun

A paint spray gun, offering close cont of the width of the "spray pattern" has been introduced by *Eclipse Air Brush C*

The "GAT-2" paint spray gun is bei manufactured by Eclipse Air Brush C

390 Park Ave., Newark 7, N. J.

Named the "GAT-2," the gun has special nozzle said to be effective in redu ing fumes, minimizing air consumptio and saving paint.

Activated Carbon

A new activated carbon, Pur-O-Carb, e pecially suitable for purifying bright nick plating solutions, is being offered by *Ha son-Van Winkle-Munning Co.*, Matawa N. J. High quality and uniformity a claimed for this material, which can al be used to purify all other acid and alkali plating solutions.

●

Welding & Joining

Electrode for Cast Iron

An arc-welding electrode, designated W 2075, has been developed by the *Apparat Dept. of General Electric Co.*, Schenectad N. Y., for producing fully machinabl welds on cast iron. It is designed to operat

MR. PRODUCT DESIGNER

Which properties of Lustrex styrene in this success story could improve your product... or lower your costs?

Monsanto also makes many other plastics and will recommend the one best suited to your needs.

Why not check with Monsanto today?

"We tenderized sales-resistance when we discarded habit-itis"

says

Wm. F. Spang
General Manager
Cube Steak Machine Co.
Needham Heights, Mass.

Housings of Cube Steak machines molded of Lustrex by Prolon Division, Pro-phy-lactic Brush Co., Inc., Florence, Mass. for Cube Steak Machine Company

"Now, our Cube Steak machines have a double-barreled sales advantage...because we eliminated habit-thinking in our research and production. Once we rejected the usual," continues Mr. Spang, "we eliminated headaches arising from chipped finishes; hard-to-get-at, hard-to-clean parts...with *new* housings made of Monsanto Lustrex styrene."

When the Cube Steak Machine Co. tossed out habit-itis, and replaced previous housings with ones of Monsanto Lustrex, they discovered how this durable, lightweight plastic could help them produce better, more sanitary machines...and win customer praise. For instance, they found the colorful finish of Lustrex goes all the way through—unlike painted surfaces, it can't peel, chip or wear off.

Housings of Lustrex are molded in *one* piece . . . are easily removed, by a flick-of-the-wrist, to get at operating parts instantly. Lustrex is smooth, and will not stain; and it is free from taste or odor. Best of all, this modern plastic is up to *nine* times lighter than some metals . . . provides more housings per pound, new savings in materials cost. Fast, *one-shot* production further lowers costs. And expensive assembling, machining, painting operations are eliminated or materially reduced.

Profit-wise manufacturers in *many* industries are banishing habit-itis in their plants...and are discovering new ways to improve old products, or to make new ones, while reducing manufacturing costs...with Lustrex, and other Monsanto plastics. How about your products? Your costs? It will pay you to send *today* for Monsanto's booklet, "What Monsanto Plastics Can Do For You." The coupon is for your convenience. Lustrex: Reg. U. S. Pat. Off.

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CHEMICALS AND PLASTICS

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Please send me, "What Monsanto Plastics Can Do For You."

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Company _____

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New Materials and Equipment

at low currents, minimizing brittle heat-affected zones in base materials.

The electrode is composed of pure nickel-core wire and an extruded black coating that is consumed in the arc, giving a low volume of slag. Good flexibility is claimed as a result of wetting action and ability to be used in all positions on either a.c. or d.c. current. The stable arc gives color-matching deposits, which offer good resistance to cracking.

Available sizes of the W-2075 electrode range from 3/32-in. dia., requiring 50 to 70 amp., to 3/16-in. dia., requiring 120 to 160 amp. All diameters are supplied in 14-in. lengths.

Silver Brazing Rings

Lucas-Milhaupt Engineering Co., 5057 South Lake Drive, Cudahy, Wis., has announced a new line of patented, stress-relieved "No Tangle" notched coil rings for silver brazing and soldering. These special rings are claimed to improve brazing and soldering by reducing material cost and assembly time, and by virtually eliminating rejects due to poor joints.

The stress relieving treatment prevents rings from distorting or creeping when

The silver brazing rings break from the coil at the notches, thus simplifying handling.

heat is applied, thus making them particularly suitable for outside diameters where brazing alloy is not held in position by the contour of parts to be brazed. The rings can also be partially stress-relieved to expand when detached from the notched coil, enabling the operator to compress them in grooves in inside diameters.

The new line also includes rings which

New Materials and Equipment

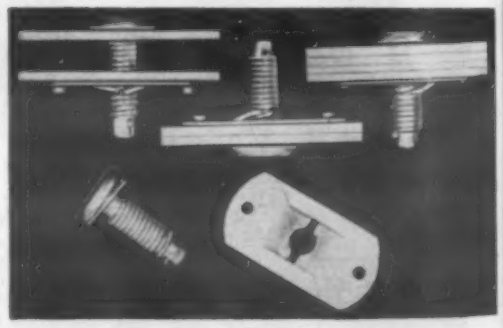
automatically lap themselves when detached and snap over outside diameters. All rings are claimed to maintain a tolerance of ± 0.001 in. in actual ring diameter or developed wire length under all conditions.

The notched coil feature is said to reduce assembly time by about 10% because the operator does not have to untangle the rings. Novel stacking is claimed to eliminate the average 10% breakage allowed for conventional preforms.

Preforms are wound from Easy-Flo, Sil-Fos and Phos-Copper. The rings are made according to job specifications and range in wire thicknesses from 0.015 to 0.094 in., with inner diameters of 3/32 to 6 in. or greater.

Vibration-Proof Fastener

A vibration-proof fastener employing a shock-absorbing spring as a thread has been introduced by *South Chester Corp.*, 1403 Finance Bldg., South Penn Sq., Philadelphia 2. Called the Southco Spring-Grip Fastener, it is claimed to remain tight under the most severe vibration or panel movement.



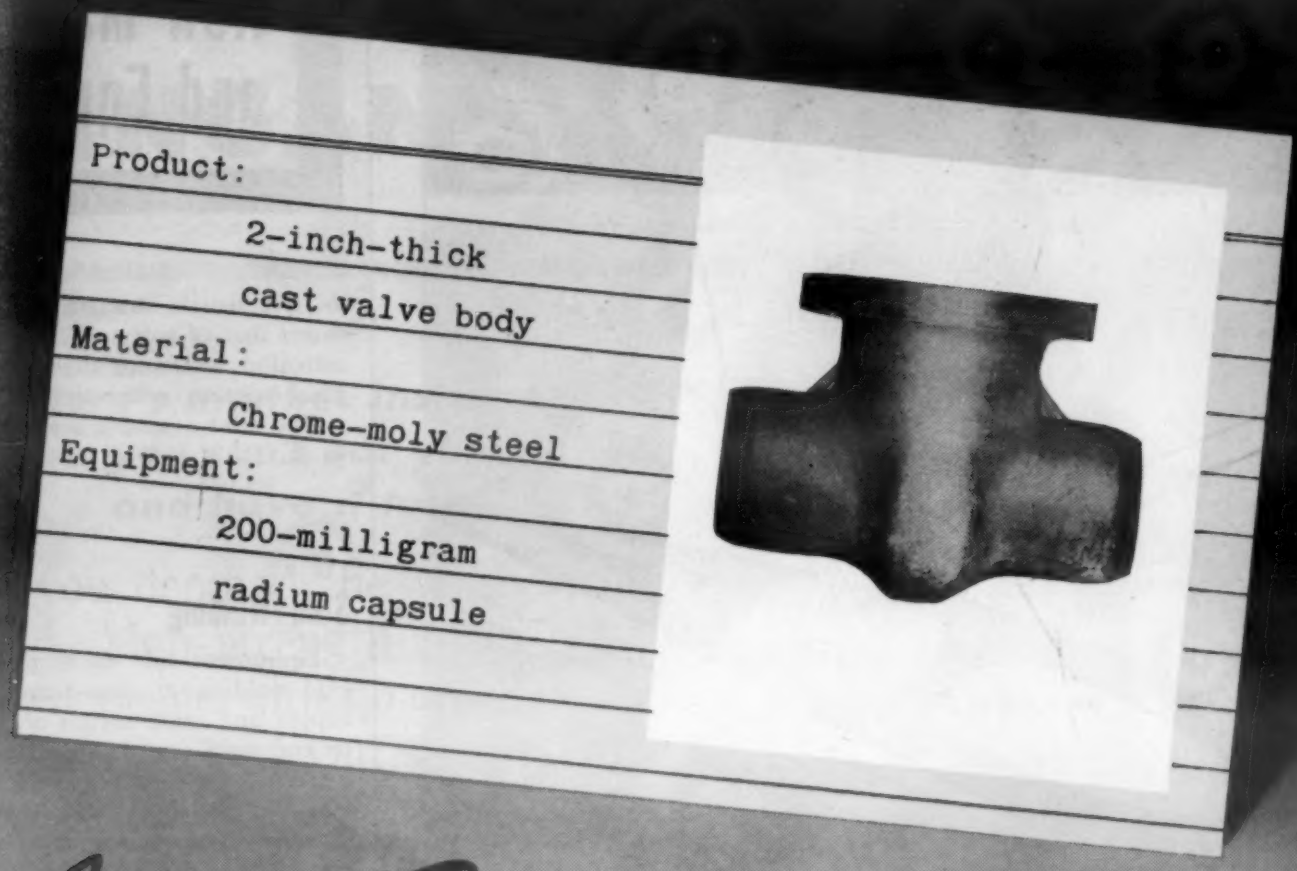
The Southco Spring Grip Fastener does not loosen under vibration.

Medium-Temperature Solder

A new solder, EutecRod 155, which has a bonding temperature of 700 F, has been developed by *Eutectic Welding Alloys Corp.*, 40 Worth St., New York 13, for joining ferrous and nonferrous metals.

The material is intended to fill the need for a solder for joining at temperatures between those of silver solders and soft solders. Silver solders join above 950 F, but this temperature produces annealing in most metals. The soft solders used below 400 F do not have sufficient strength for many purposes. The new alloy is claimed

WHAT'S THE RIGHT X-RAY FILM?



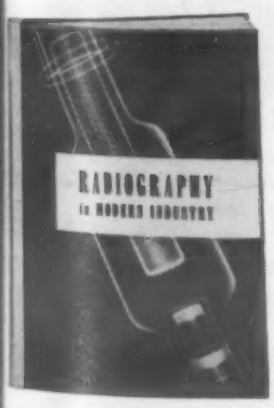
ANSWER:

KODAK INDUSTRIAL X-RAY FILM, TYPE K

This 20-inch valve body with its 2-inch-thick walls was radiographed with Kodak Industrial X-ray Film, Type K.

The radiographer chose this type because it has high speed to do heavy jobs like this with the shortest possible exposure time. In this case, exposure of only 30 minutes was sufficient.

With all its high speed, this film provides good radiographic quality to make sure that no significant imperfections in the casting will be missed.



RADIOGRAPHY IN MODERN INDUSTRY

A wealth of invaluable data on radiographic principles, practices, and technics. Profusely illustrated with photographs, colorful drawings, diagrams, and charts. Get your copy from your local x-ray dealer—price $3.

A TYPE OF FILM FOR EVERY PROBLEM

To provide the recording medium best suited to any combination of radiographic factors, Kodak produces four types of industrial x-ray film.

* * *

Type K has medium contrast with high speed. For gamma rays and for x-ray work where highest possible speed is needed at available kilovoltage without calcium tungstate screens.

Type F provides the highest available speed and contrast when exposed to x-rays with calcium tungstate intensifying screens. Has wide latitude with either x-rays or gamma rays, exposed directly or with lead foil screens.

Type M provides maximum radiographic sensitivity, high contrast, and exceptional detail under direct exposure or with lead foil screens. It has extra fine grain, and the speed is adequate for examination of light alloys at average kilovoltage and for much million-volt radiography.

Type A offers high contrast with about three times the speed of Type M but with slightly more graininess. Used direct or with lead foil screens for study of light alloys at low voltages, and of heavy steel parts with 1000-kv x-rays or gamma rays.

EASTMAN KODAK COMPANY
X-ray Division · Rochester 4, N. Y.
"Kodak" is a trade-mark.

Radiography

...another important function of photography

Kodak

New Materials and Equipment

to have tensile strength about midway tween that of soft and silver solders, be corrosion resistance than soft solders, good wetting properties.

Rod sizes available are 1/16-, 3/32- ⅛-in. dia.

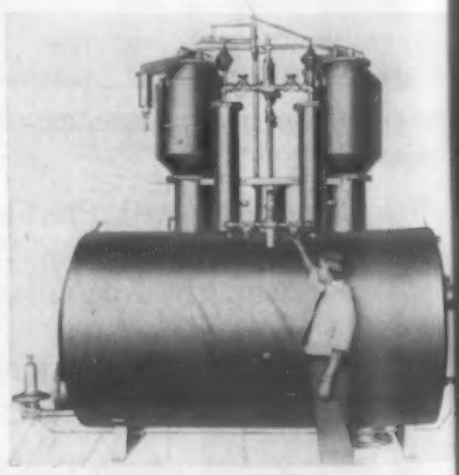
Stud Welding

Equipment and studs for the inert- stud welding of aluminum, stainless st copper and other metals ordinarily diffi to end weld are now being supplied co mercially by *Shielded Stud Welding C* 124 W. Fourth St., Los Angeles 13, Ca This new process is claimed to be the fi one by which consistently satisfactory w welds can be made for some of these met

Acetylene Generator

A new stationary type generator wh produces a continuous flow of acetylene h been developed for plants and weldi shops requiring large quantities at ma mum cost and maintenance. The genera is being manufactured by *Sight Feed G erator Co.*, West Alexandria, Ohio.

The "A-Twin" unit can be operated any desired pressure up to 13 psi. It



Continuous flow of acetylene for weldi is provided by this "A-Twin" generat

available in five sizes, with production pacities ranging from 500 to 2400 cu. of gas per hr.

The generator requires a minimum attention during operation. The automat feed hoppers must be refilled with calci carbide when empty, and the requi amount of water must be metered into t tank. When the carbide supply in one ha is exhausted, the second hopper automa cally goes into service.

Plain Facts About MANGANESE ELECTRODES

Here's another instance where you can't eat your cake and have it too!

If you demand the ultimate in sound, high-strength manganese weld deposits with no cracking or checking . . . you can get it with BARE STOODY MANGANESE electrodes. If you are willing to sacrifice high "physicals" produced by these bare rods for the sake of somewhat easier application . . . coated rods may do the job.

After a little experience, welders will find the NEW STOODY MANGANESE bare electrodes almost as easy to handle as many of the current coated rods. They will notice immediately how smoothly it lays down and its freedom from any tendency to crack. *Here is a manganese that is REALLY DIFFERENT—and better!*

In as-welded deposits, Bare Stoody Manganese produces these unusually high physical properties. We believe there are none better:

Ultimate Tensile Strength—85,000 psi; Yield Point—61,000 psi; Elongation in 2"—18%; Reduction of Area—18%; Hardness (as deposited)—165-175 Brinell or 85-90 Rockwell B; Hardness (work hardened)—375-425 Brinell or 45-50 Rockwell C.

While we supply coated manganese, we earnestly suggest a thorough test of Bare Stoody electrodes . . . *for greater toughness . . . higher impact strength . . . full Hadfield properties . . . fast burn-off . . . low penetration . . . unusually good arc characteristics.*

For your next job order bare manganese from your Stoody dealer. Compare this rod with anything you've seen before. We're glad to leave the future choice in your hands. Literature is available.

STOODY COMPANY

11959 East Slauson Avenue • Whittier, California

New Materials and Equipment

Forming & Machining

Metal Shear

The Tru-Edge Shear, capable of cutting irregular shapes in either mild or stainless steel sheets up to 3/16 in. thick, has been announced by *Baker Bros., Inc.*, 1000 Port St., Toledo 10, Ohio. Also suitable for nonferrous metals, the shear has an attachment for circle cutting and strip cutting and can be used to cut to a scribed line or by template.

The Baker shear has a 48-in. throat and variable stroke adjustment; it is powered

The Baker Tru-Edge Shear will cut stainless sheet up to 3/16 in. thick.

by a 1½-hp. totally enclosed ball bearing motor, 220 or 440 v., 3 phase, 60 cycles. No starting hole is required for inside cuts.

A simple exchange of hammer-type dies for the cutting tools enables the machine to perform diverse bending and forming operations in steel up to ⅛ in. thick.

Milling Machine

A new milling machine, having full No. 3 range and powered by a 7½-hp. motor, has been announced by the *Cincinnati Milling Machine Co.*, Marburg Ave., Cincinnati 9, Ohio. Designated No. 3MI, and available in plain and universal styles, the new series is an extension of the 2ML and 2MI lines announced about four years ago.

Wide speed and feed ratios—60 to 1 and 120 to 1, respectively—and controls making possible rapid and easy changes in speeds and feeds are featured on the 3MI machine. Sixteen spindle speeds, ranging from 25 to

looking for the unusual in stainless strip steel?

Meet the THINSTEEL Man

The CMP stainless Thinsteel man is a character—an unusual character because he represents something unique in stainless strip. He's a salesman for a mill primarily interested in developing new applications for the 300 Series stainless grades in unusual sizes, finishes and physical properties.

This Thinsteel man is always on the lookout for inquiries involving fussy finishes, tight tolerances or tricky tensiles. He makes a business of doing the commercially impossible. He can offer you such uncommon products as 18-8 stainless in *dead soft temper, with a bright finish on both sides;* or strip with total gauge variation from edge to edge held to *less than 25% of standard;* — or strip *as thin as .001",* just to cite a few of the specialty products he likes to sell. If he sometimes appears over-enthusiastic, it's because he's really sold on his mill's ability to come up with the right answer to difficult and unusual problems and he knows that the organization behind him is equally interested in maintaining the CMP reputation for *the best in light-gauge stainless strip specialties.*

Your request for help in developing specifications to meet functional or fabricating problems will bring prompt and interested attention from the nearest Thinsteel representative.

CMP THINSTEEL PRECISION COLD ROLLED CMP STRIP STEEL

the Cold Metal Products co.

YOUNGSTOWN 1, OHIO

NEW YORK • CHICAGO • DETROIT • ST. LOUIS • INDIANAPOLIS • LOS ANGELES

New Materials and Equipment

1500 rpm., are changed with a single cra type control which operates a hydrau selector valve. While the spindle is rotatin a safety interlock prevents the speed chan crank from being moved. A mechani spindle reverse, located just below t

The new Cincinnati 3MI is the largest this company's family of milling machi

speed change crank, offers quick rever of spindle rotation with no effect on t direction of feeds.

Feed rates are changed in the same ma ner as speeds, through a range from ¼ 30 in. per min. All operating controls the machine are duplicated at the re working position.

Tool Hardening

A secondary hardening process for to which have been hardened, tempered a ground to size has been announced *Sol-ven-ite Laboratories,* 3928 Elstron Av Chicago 18, Ill.

The Sol-ven-ite treatment is used o on high-speed steels and is claimed to ha resulted in greatly increased service l for high-speed drills, reamers, taps, chase counterbores, milling cutters and for tools. No distortion or dimensional chan are produced.

Toolpost and Bench Grinder

A dual-purpose toolpost and ben grinder, called the Utility Grinder, h been announced by the *Dumore Co.,* R cine, Wis.

Claimed to be accurate to 0.0002 i the ¼-hp., 5000-rpm. Utility Grinder lathes of 9- to 13-in. swing for exter

Ever stretch a backbone to hold 500 ribs?

Courtesy Rittling Corp.

u need plenty of spinal column in king this convector radiator section. er 500 ribs, or fins, are attached to its ular backbone—and the attaching, while in- ious, is tough on the tube.

Assembly is made by dropping the fins into a slotted jig, erting the tube, and ramming terrific pressure through tube to expand it into a jam fit with the fins. In the ocess the tube O.D. between fins is enlarged by thirty thou- dths—actually creating a groove to firmly hold each fin. Where does the fabricator find tubing to fill this unusual vice demand? Right from Frasse. Frasse has supplied the mless tube for this requirement since its beginning in 6. And in 4 years of this grueling application—in tens of usands of feet put to this exacting test—*there has never en a single failure.*

If it's trouble-free quality you like, you'll like the tubing sse ships you. And when you work from Frasse stocks, you've plenty to work with. For Frasse warehouses stock over 1200 tube sizes alone—from 3/32″ to 24″ O.D., in wall thickness from .022″ to 1″. And for technical assistance, you'll find Frasse engineers always ready to help analyse the profit potential of tubing in your product. Call Peter A. FRASSE and Co., Inc., *17 Grand St., New York 13, N. Y. (Walker 5-2200) • 3911 Wissahickon Ave., Philadelphia 29, Pa. (Baldwin 9-9900) • 50 Exchange St., Buffalo 3, N.Y. (Washington 2000) • Jersey City • Syracuse • Hartford • Rochester • Baltimore*

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Seamless and Welded Mechanical Tubing

Aircraft, Condenser, Hydraulic and Pressure Tubes

Stainless Tubing, Seamless and Welded

Stainless Pipe, Valves and Fittings

Want to save with SEAMLESS TUBING?

"Mechanical Applications" is a *new* 24 page booklet especially prepared to familiarize you with the many ways in which seamless tubing can be economically used in your product. Packed with ideas and suggestions, it can be the source of additional profit for you. Send the coupon for your *free* copy today.

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Please send me, without obligation, a copy of your new, helpful tubing booklet entitled "Mechanical Applications.

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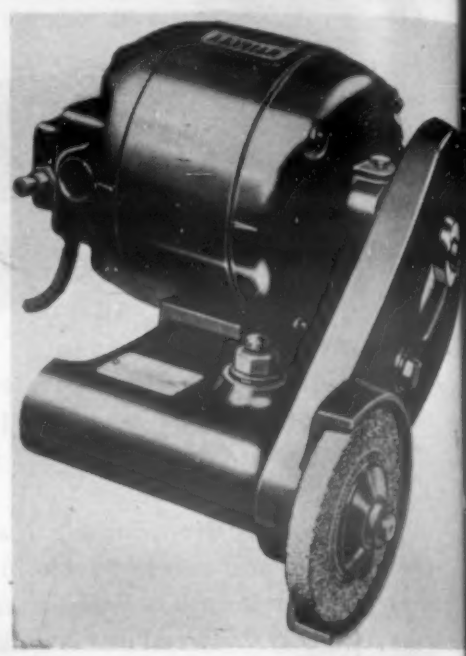
New Materials and Equipment

cylindrical grinding and mounts on sha planer or milling machine for surf grinding. When not needed for preci work, it can be quickly converted to be



The Utility Grinder manufactured by Dumore Co. can be used for both ordi and precision grinding.

use for burring castings, cleaning we wire brushing, polishing and tool sharp ing. These features make available a fl ible, low-cost machine for handling b everyday production jobs and special gri ing jobs in small shops.

●

Casting & Molding

Core Sand Binder

A synthetic thermosetting resin develop especially for use as a core sand binder h been announced by *Monsanto Chemi Co.,* 1750 S. Second St., St. Louis 4, Mo

Use of Resinox 4846 is claimed to ma possible lower core sand costs in the fou dry as well as cleaner castings having bet surface finish, greater detail and l tendency toward veining, scabbing, spalli blows and hot tears.

Small Die Casting Machine

A 1-lb. capacity, fast-operating zinc all die casting machine, Model M55 A/H 1P, is now being marketed by *DCMT D Casting Machine Corp.,* Dept. 50, 1

It pays to use your custom molder's know-how

when you want precision-fitting parts

No. 17 in a series on Plastics Skill at Work...

PROJECT:
One-piece case for adding machine

CUSTOMER:
L C Smith & Corona Typewriters Inc
Syracuse, N. Y.

MOLDER:
Northern Industrial Chemical Co.
South Boston, Mass.

MATERIAL:
Medium impact Durez phenolic plastic

MOLDED-IN ribs add to rigidity of long side panels, are undercut to permit ready attachment and detachment of the case. Case is delivered from the molder with undercuts cut in and completely checked for tolerances.

OFFICE MACHINE SERVICE CONDITIONS emphasize non-resonance. The marked sound-deadening effect of the phenolic case helps to reduce noise at the source.

CORNER HOLES are molded in and fit over four locating pins on the machine. Good molding technique assures accurate position of holes and rib undercuts.

If you are interested in reducing the xpense involved in a multiplicity of ols and jigs, then this L C Smith & orona adding machine housing of urez plastics may suggest a profitable ne of procedure.

Although it is molded in one-piece, is so well designed and produced at it meets the rigid tolerances inolved in work of this nature. The only achining is a simple undercut at the sides, which is done by the molder.

Cooperating with Smith-Corona executives, Northern Industrial Chemical Co. plastics men shared in working out thick and thin wall sections, allowances for cooling and shrinking action, and various details that contribute to rapid assembly.

Here, as in jobs that you may undertake, the custom molder came into the picture with a thorough knowledge of Durez phenolic plastics. The most versatile of all plastics, phenolics have flow and strength properties that permit great latitude of design. Eight distinct classes of Durez phenolics permit your engineers to select the mechanical, electrical, and chemical characteristics that suit their specific needs.

Durez technicians will be glad to work with you and your molders. Please feel free to call on them anytime.

A bit with plastics users everywhere is the handy "Durez Check-Chart." Write for yours. Durez Plastics & Chemicals, Inc., 145 Walck Rd., N. Tonawanda, N. Y.

DUREZ

PHENOLIC RESINS

- MOLDING COMPOUNDS
- INDUSTRIAL RESINS
- PROTECTIVE COATING RESINS

PHENOLIC PLASTICS THAT FIT THE JOB

New Materials and Equipment

Duane St., New York 13. It utilizes single impression dies.

Average production of 500 to 700 shots per hr. can be maintained by this machine and die sizes up to 6 by 9 in. can be used.

This small DCMT die casting machine is economical for as few as 2000 pieces.

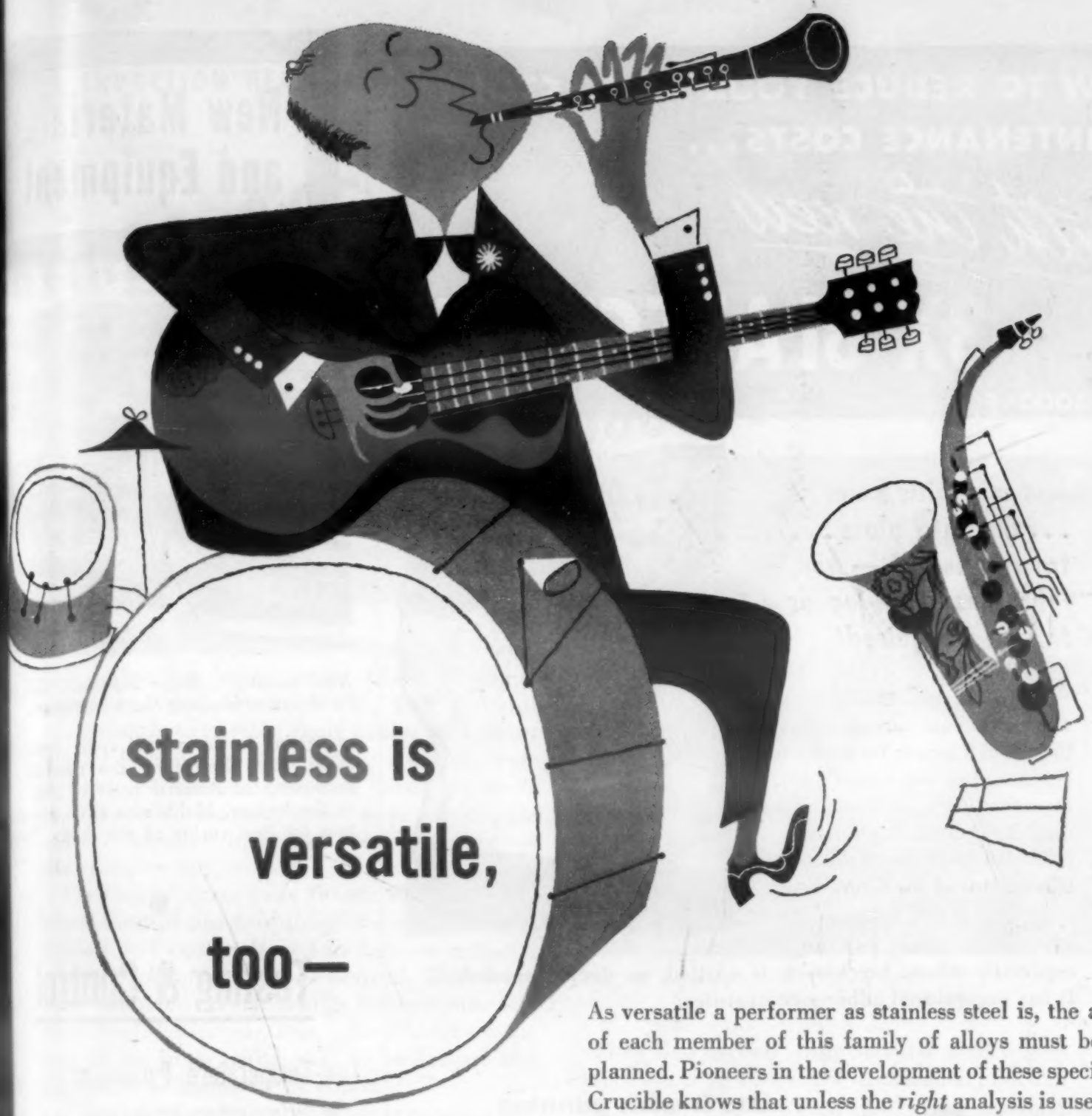
Small prefabricated die blanks are supplied with the machine, and cavities can be machined directly into these blanks. This method of die fabrication, combined with high-speed cycling, is said to make possible economical production runs as low as 2000 pieces. The machine weighs 470 lb. and requires 24- by 12-in. floor space.

Injection Molding Heater

A new heating cylinder, especially designed for the injection molding of thermosetting products, has been developed by *General Machine & Tool Works*, Walled Lake, Mich., and is being sold through *Reed-Prentice Corp.*, Dept. P, Worcester 4, Mass.

The Kovac Injection Molding Heater can be installed on any Reed-Prentice 10-D machine now in use and is said to be readily interchangeable with thermoplastic heaters.

The Kovac process includes controlled



As versatile a performer as stainless steel is, the application of each member of this family of alloys must be carefully planned. Pioneers in the development of these specialty steels, Crucible knows that unless the *right* analysis is used, stainless may prove disappointing. That's why Crucible offers you the services of an alert staff of metallurgists and engineers to help you apply stainless . . . properly. These engineers and metallurgists have all the wealth of experience that Crucible's half century of specialty steel leadership provides . . . take full advantage of it.

Whatever your stainless application may be, Crucible is prepared to help you. Whether the order is in pounds or tons, Crucible tackles every industry-posed problem with a keen devotion to detail. If you're thinking of stainless . . . call in Crucible. CRUCIBLE STEEL COMPANY OF AMERICA, Chrysler Building, New York 17, N. Y.

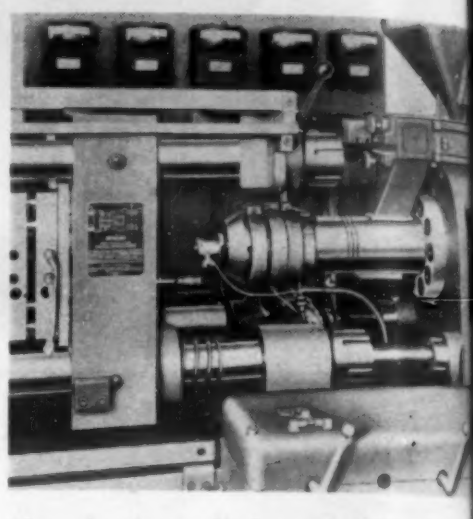
CRUCIBLE first name in special purpose steels

STAINLESS STEELS

fifty years of Fine *steelmaking*

STAINLESS • HIGH SPEED • TOOL • ALLOY • MACHINERY • SPECIAL PURPOSE STEELS

New Materials and Equipment



New heating cylinder especially design for injection molding thermosetting plasti

preheating in the normal cycle of the m chine, thus eliminating the necessity f preheating of material prior to placing in the hopper. Molds also have controll heat for final curing of the shot.

Testing & Control

Low-Temperature Pyrometer

A surface pyrometer designed to measu temperatures between 0 and 150 F h been introduced by *Illinois Testing Labo tories, Inc.*, 420 N. LaSalle St., Chicago Ill. Known as the Alnor Type 2300 Su face Pyrometer, the instrument is calibrat at one degree per division, thus allowi more accurate measurements than a usually possible.

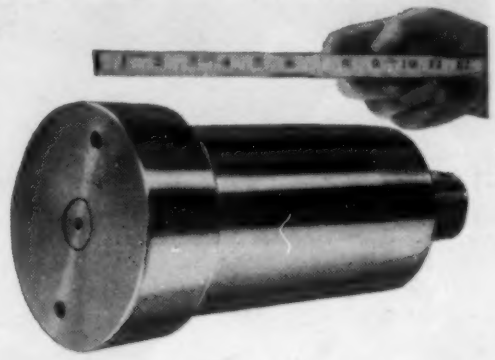
Film Thickness Gage

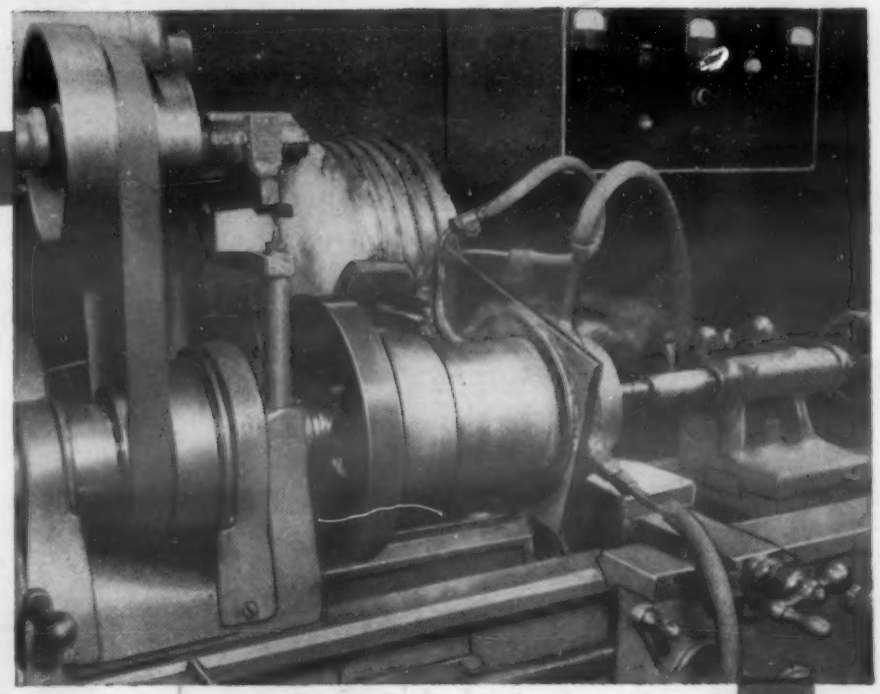
An accurate method for measuring t thickness of attached dry films and th sheet metals, foils, paper or plastic has be developed by *Interchemical Corp.*, 350 Fift Ave., New York 1. The equipment, whic employs the Interchemical Direct Readi Thickness Gage previously developed f wet-film measurements, is being manufa tured by *Henry A. Gardner Laborator Inc.*, 4723 Elm St., Bethesda, Md.

Attached dry films are measured visual by means of an optical attachment to t gage plus a suitable light source. The fil is stripped at two points about ½ in. ap and the two outside gage wheels rest these stripped areas. Then the gage is r tated until its eccentric center wheel touch

INDUCTION HEATERS ON THE JOB: **PROGRESSIVE HARDENING**

avings: $25 per pin...
ewer operations...
variety of parts processed





HARDENING CROSSHEAD PINS with their G-E induction heater saves Clark Brothers Company, Inc., Olean, N. Y., $25 per unit . . . enough to pay for their heater in a short time! Clark passes this saving along by furnishing additional induction hardened parts per unit with no additional cost to the customer. Result—increased serviceability of the compressor.

Previously these pins (about five inches in diameter and one foot long) were carburized, cooled and counterbored to remove material where hardening was not desired. They were then reheated to hardening temperature and quenched. Following this, a small area on the end of the pins, which was to be drilled and tapped, was annealed by torch.

The *entire hardening operation* is now accomplished in a *single pass* through the work coil of the G-E induction heater! And this is only *one* operation Clark Brothers perform with their induction heater.

They also harden lands on valve seats which vary from 3 to 10 inches in diameter; harden the ends of setscrews; and progressively harden piston rods 1½ to 4½ inches in diameter and 3 to 13 feet in length.

Net result: parts hardened better, faster, and at lower cost with a G-E induction heater.

SEND FOR YOUR FREE COPY!

"Induction Heating in Industry"

Sect. C720-15, Apparatus Department,
General Electric Co., Schenectady 5, N. Y.

Please send me your bulletin GEA-4945 which describes how dozens of manufacturers have put G-E induction heaters on the job to cut costs and speed up production.

For: ____Reference purposes, ____Planning immediate project

Name _____

Position _____

Company _____

Address _____

City _____ State _____

YOUR PRODUCT AND INDUCTION HEATING

If you are annealing, brazing, soldering or hardening parts of your product, you can very likely do the job better, faster, and at lower cost with G-E induction heaters. Just contact the G-E Sales Office nearest you; we'll be glad to recommend the cost-cutting equipment best suited to your particular heating jobs.

You can put your confidence in

GENERAL ELECTRIC

720-15

New Materials and Equipment

the film. A light source placed behind t gage permits the observer to check the po at which the center wheel meets the fi and cuts off light.

For measuring thin metal sheets, fo paper and plastic films, the gage rests on plane surface with its eccentric center wh at maximum reading. A narrow strip of t sheet material is placed on the plane s

The Interchemical thickness gage has b adapted to measurement of dry films thin sheet materials.

face between the two outer wheels. T the gage is rotated over the strip unti slight binding is noticed; reading at t point gives the thickness. Great preci in these measurements is claimed bec no pressure is exerted against yield surfaces.

Pocket-Size Hardness Tester

A pocket-size surface hardness tes instrument for quality control is now be marketed by *Peabody Industries, Inc.*, 1 Penobscot Bldg., Detroit 26, Mich.

The Metalometer is claimed to give stant, accurate readings on Brinell, R well B and Rockwell C scales. It will

The Metalometer offers a convenient me of quality control.

mar the surface of the work being te In operation, the instrument is placed the surface to be checked, a hamme released, and accurate readings are avail in less than a second.

BEETLE* plastics thrive on "slaving" in the kitchen all day long!

BEETLE Plastic is ideal for products and parts made for the "most used" room in the house—the kitchen. Here are *a dozen* good reasons why:

1—BEETLE Plastic is resistant to wear, breakage, abrasion; has nothing to wear off. 2—It is light, yet strong. 3—Won't soften, warp, get hot. 4—Chemically inert, it won't be hurt by common solvents or grease and it resists food acids. 5—Easy to clean and keep clean. 6—In white its sanitary appearance matches other kitchen equipment. 7—Odorless, tasteless. 8—Good insulating properties. 9—Smooth-textured, lustrous. 10—Available in wide range of beautiful, permanent colors. 11—Has easy moldability. 12—It's adaptable to mass production.

Enough said? Let's talk about *your* product and fast-cure, low-cost BEETLE.

AMERICAN Cyanamid COMPANY

PLASTICS DEPARTMENT
34M ROCKEFELLER PLAZA, NEW YORK 20, N. Y.

*®

BEETLE* plastics—urea-formaldehyde thermosetting molding compounds. MELMAC* plastics—melamine-formaldehyde thermosetting molding compounds, industrial and laminating resins. URAC* resins—urea-formaldehyde thermosetting industrial resins and adhesives. MELURAC* resins—melamine-urea-formaldehyde thermosetting resin adhesives and laminating resins. LAMINAC* resins—thermosetting polyester resins.

News Digest

CONTINUED FROM PAGE 57

an odor to the finished material. Th is a dioctyl adipate of low acid co tent. With it, vinyl compounds c retain a high degree of elasticity temperatures as low as −70 F, wh at the same time, the plasticizer efficient enough so that the quant required will not unduly lower t physicals at room temperature.

Bakelite Div. of Union Carbide Carbon Corp., in the show with bo its phenolics and its thermoplas resins, announced a new series general-purpose phenolics with c ing rates 15 to 45% faster than t standard phenolics that have be considered fast curing. Chemic physical and electrical properties the new high-speed material will substantially equal to those of standard general-purpose phenoli Production rates have been increas from 15 to 100% by use of the n molding material, according to suppliers.

Styrene and vinyl polymers as co ings for insulating boards and pap and new products of polyethylene the packaging and housewares fie were also part of Bakelite's displ Window shades of vinyl sheet supplement the window drapes the same material, it was announc

Molding Presses

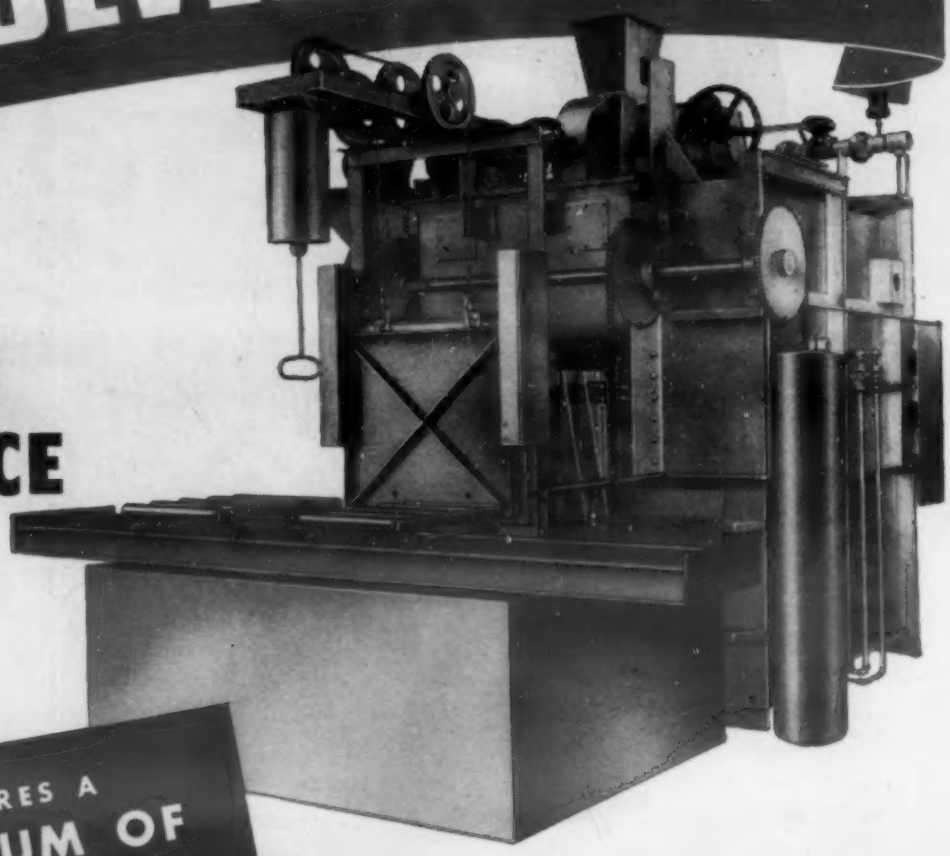
Plaskon Div. of Libby-Owens-Fo Glass Co. continued to feature alkyd molding compound with demonstration of three new hi speed molding presses recently p duced to bring out the possibili of the quick-setting resin. Th presses, in the $1500 to $3000 pr class, are especially developed leading press builders to take adv tage of the exceptionally short cy possible with the alkyd. The unu ally low price for a fully automa press is a result of this design.

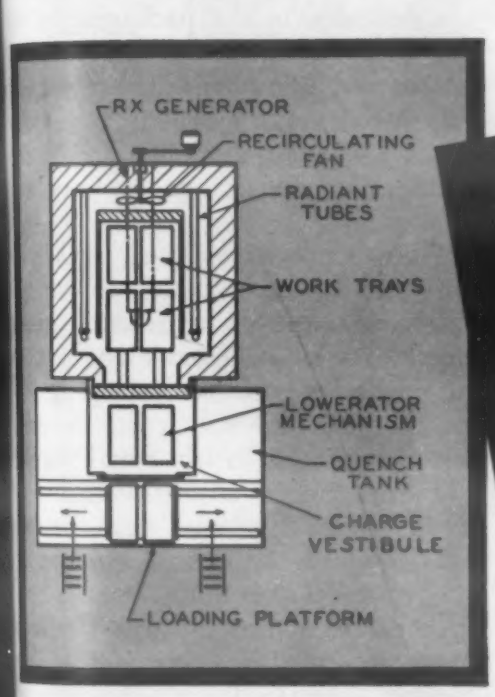
A method for preparation of gr ular molding material was dem strated by Monsanto Chemical C Plastics Div. Dry coloring of styr crystal compound by simple tu bling in drums may solve some the problems for the molder w must make up a wide range of co in his molding material, and can conveniently or economically keep these colors in stock. Any color m ing material can be made up fr

A New AND IMPORTANT DEVELOPMENT

'Surface' HIGH PRODUCTION BATCH-TYPE FURNACE

***WITH BUILT-IN RX ATMOSPHERE GENERATOR**





REQUIRES A MINIMUM OF CAPITAL INVESTMENT PER POUND OF CAPACITY

★ **HIGH-RATE BATCH PRODUCTION** . . . Heats a gross load up to 200 lbs. per hr. per sq. ft. of hearth area, depending upon work and type of loading. Gross charge capacity of furnace up to 2500 lbs.

★ **LOW COST** . . . minimum investment for each pound of capacity. Light case cyaniding can be done for less than one-half cent per pound of work, exclusive of burden and fixed charge.

★ **EXTREME FLEXIBILITY** . . . especially adaptable to *Gas Carburizing, Carbon Restoration (Skin Recovery), Dry (gas) Cyaniding, Homogeneous Carburization, Clean Hardening, and for General Heat Treating.* Recommended for miscellaneous parts such as bolts, screws, fittings, etc., and straight shafts up to 12-13 inches long.

★ **'SURFACE' RADIANT TUBE HEATING** . . . with baffle between the work and the tubes.

★ **FASTER HEATING** . . . fan is used to circulate the heated prepared gas atmosphere around the work to secure a higher rate of heating and improve contact with the load.

★ **BUILT-IN 'SURFACE' ATMOSPHERE GENERATOR** . . . eliminates the need for an external generator, resulting in fuel and floor space economies.

★ **LOADING AND UNLOADING MECHANISM** . . . consists of two alloy screws to move loaded trays in and out of furnace. Furnace holds four trays at a time.

★ **AIR COOLING OF WORK** . . . can be done in the charge vestibule, or—

★ **LIQUID QUENCHING** . . . a lowerator mechanism provides means for oil quenching loaded trays in quench tank built adjacent to front of furnace beneath charging vestibule.

★ **SAVES FLOOR SPACE** . . . overall dimensions approximately 16-feet long (including quench tank) by 9-feet wide by 13-feet high. Occupies only 144 square feet of floor space.

DESIGNED FOR GREATER ECONOMY OF PRODUCTION

'Surface' researchers and engineers have combined all the time-proven features of furnace design into a unit that meets all the requirements for LOW COST, HIGH PRODUCTION of heat treated pieces.

Investigate its Cost Reducing Possibilities for your plant — Today! There is no obligation.

*Optional

SURFACE COMBUSTION CORPORATION • TOLEDO 1, OHIO

'Surface' INDUSTRIAL FURNACES

News Digest

dry colorant and styrene crystals within about half an hour. There is some sacrifice of uniformity in color, and matching may not be as accurate, but the loss should not be important except for critical work.

Packaging Film

Dow Chemical Co., which has released its trade name Saran to become a generic term for vinylidene chloride polymer, displayed some of the new products of saran film and filaments. The film has gone into the packaging field, where its transparency, absence of taste or odor, pliability at low temperatures, and high vapor-barrier properties are especially desirable in the packaging of wet or moist foods. Pickles in brine, dried fruit, and ground meats are some of the products for which it is being used. Woven filaments are finding increasing acceptance as upholstery materials.

Dow's polystyrene was used in the molding of a ukulele, an unusual piece of work in which the instrument, assembled from eight separate moldings, is produced at a price lower than that of the wood-and-metal article. Savings in labor make up the difference in the cost of the materials. Other items displayed were toys, rigid containers, household utensils, etc.

Extrusion of cellulose acetate butyrate coatings directly over steel tube was a featured development of Tennessee Eastman Corp. The tube, of 2- to 3-in. dia. for many applications, is covered with a tightly adhering coat of the plastic about 1/16 in. thick, and in any of a wide range of colors. The coating will not chip, and the tube can even be bent after coating. Such tubes are used for stanchions and grab rails in busses, for seat arms, etc.

Cellulosics Applications

Plant covers of transparent cellulose acetate butyrate, lasting about five years, are gaining against the paper covers used for protection of growing truck crops. The paper covers had a life of a few weeks to a few months. In addition to the longer life, largely offset by the higher cost of the plastic, the transparent shields permit the plants to mature about two weeks earlier. Irrigation tubes, light in weight and noncorrod-

News Digest

ing, transparent jars for food packaging, traffic markers, conveyor rollers, pneumatic conveyor tubes, and tool handles were other items of cellulosics. An extruded sheet stock, in all colors and clear and transparent, has been produced for fabricators.

Westinghouse and U. S. Plywood Corp. are cooperating in the production of Micarta-Weldwood composites, now available in various combinations of colors, textures and materials. It is used in furniture, fixtures and building interiors; and in railway coaches, busses, and aircraft. The new range of colors permits a wider scope and better color harmony to the user.

American Cyanamid Co.'s polyester resins are going into tote boxes for bakeries, electrical parts, steam vaporizers, sterilizers, etc., indicating the expanding uses of these thermosets. A boat hull molded in one piece is made of the resin with glass fiber mat as the reinforcing material. Wrinkle-resistant and water-resistant cloth uses the melamine resin to confer these properties.

Annealing Polystyrene Parts

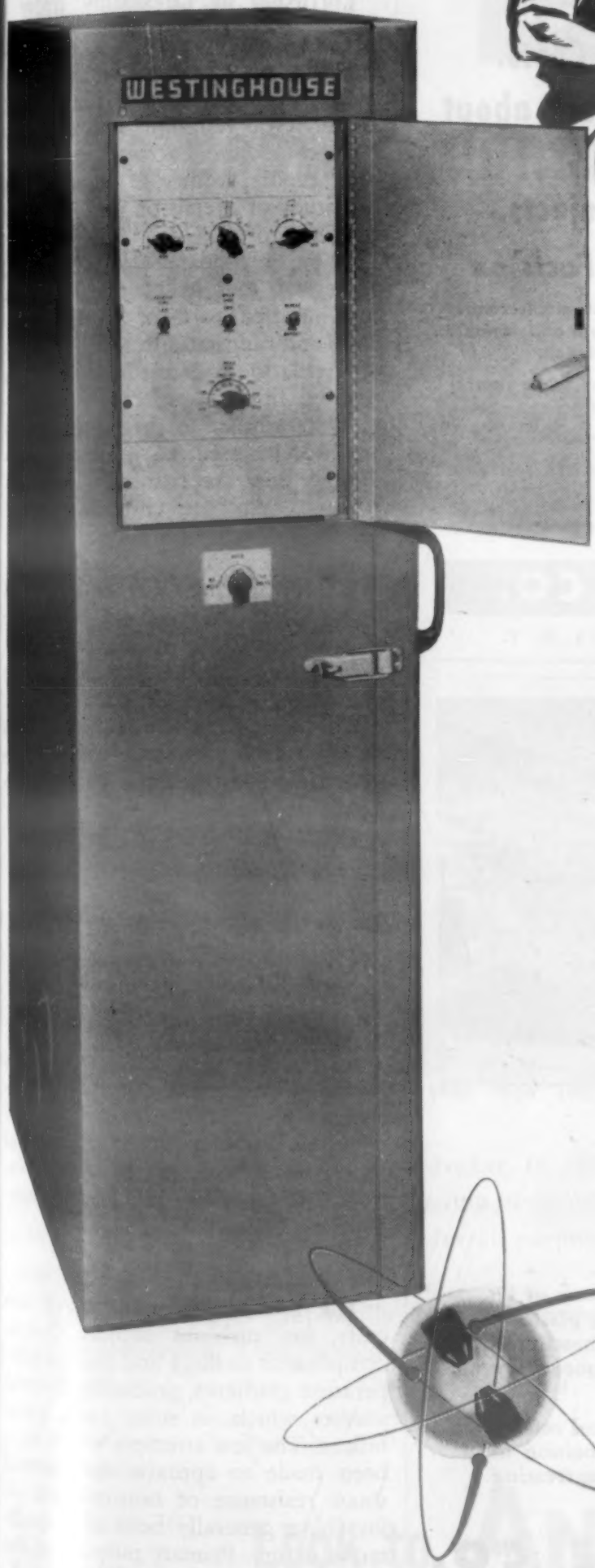
Koppers Co.'s display stressed the importance of annealing polystyrene molded parts to obtain best physical properties. Heating in air or water for about 2 hr. at 160 to 170 F will relieve the stresses locked up during molding or extruding. In many cases the piece can be annealed in the molding machine.

U. S. Rubber Co. displayed some of the materials into which its new blended material, Royalite, is going. Luggage, typewriter cases, aircraft window frames, fan blades, sewing machine cabinets, and railway car panels are typical. The material is also produced in a lightweight, expanded form for insulation, soundproofing, floats for pontoons, and the like.

The acrylics are rapidly taking a place in the automotive industry as the preferred material for transparent molded ornaments, tail light lenses, etc. Electric signs of translucent plastics are competing with fluorescent lighting and with enameled steel display equipment. Nylon zippers, plastic-covered dough rolls, and polystyrene phonograph records were some of the other applications for plastics shown.

YOU CAN BE **SURE**.. IF IT'S

Westinghouse



It's Fully Electronic

...to limit costly outage time!

A resistance welding control is one of the busiest things we can think of. Imagine the intense activity as it performs over a thousand precise timing and switching functions in a single minute's operation. Little wonder it takes equipment that doesn't get tired or break down under load.

The electronic tube has qualities that make it particularly well suited for this kind of duty. It's not subject to fatigue, and it can work at tremendous speed indefinitely. That's why the new Westinghouse Control is completely electronic. Timing functions are now performed electronically. The result is a gain in precision with practically no moving parts. Fewer moving parts mean fewer control breakdowns . . . less costly outage time . . . savings that more than repay the cost of the equipment.

Booklet, B-4309, just off the press, explains all the advantages of this remarkable new control. You'll see how it's easier to install, easier to operate and maintain . . . how it's adaptable to spot, butt or projection welding. For your copy, write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-21537

Westinghouse

RESISTANCE
WELDING CONTROL

News Digest

New Colorless Compounds Inhibit Corrosion by Circulating Water

Corrosion of iron and steel by circulating water can be almost completely prevented by addition of small amounts of tungsten and molybdenum compounds, according to a recent report from the Institute for the Study of Metals of the University of Chicago.

A paper prepared by William D. Robertson revealed that dissolving a few hundred parts of alkali molybdates and tungstates in a million parts of circulating water or brine will stop rusting. In this respect, these materials are similar to chromates, which are widely used as inhibitors. Although they are currently more expensive than the chromates, these colorless compounds are expected to be useful where the vivid yellow color of the chromates makes them undesirable. The new inhibitors are also expected to prove as effective as chromates in protecting aluminum and magnesium against corrosion.

The exact mechanism by which these rust-inhibitors work is still unknown and is the subject of the investigations which revealed the new inhibitors.

Relative Thermal Shock Resistance Determined for Six Cast Alloys

Results of an investigation undertaken to determine the relative resistance of six cast high-temperature alloys to cracking caused by thermal shock have been reported by the National Advisory Committee for Aeronautics *(Technical Note 2037)*.

Gas Turbine Heating Cycles

The operating conditions of aircraft gas turbines subject certain components to large and sudden temperature gradients, producing thermal stresses which, in some cases, cause failure. The few attempts which have been made to appraise the thermal shock resistance of heat-resistant alloys have generally been of a qualitative nature. Primary purpose of the investigation by M. J. Whitman, R. W. Hall and C. Yaker was to evaluate the relative resistance of certain

News Digest

high-temperature alloys to thermal-shock cracking.

The evaluation unit utilized a controlled water quench of the symmetrical edge of a uniformly heated, modified wedge-shaped specimen. The specimens were heated at a uniform temperature of 1750 F for 1 hr. and water quenched to 45 F. This cycle was repeated until thermal shock failure occurred. The order of decreasing resistance to thermal-shock cracking of the alloys was: S-816, S-590, Vitallium, 422-19, X-40 and Stellite 6.

The heating and quenching cycle produced elongation of the quench edge, and measurements of these deformations were made during the cyclic tests. Total elongation of the quenched edge at failure was found to increase with the resistance of the material to thermal shock.

No Correlation Found

Materials having similar thermal properties, such as coefficient of linear expansion, conductivity and specific heat, were found to have widely differing resistances to thermal shock. Metallurgical examination of the alloy structural and study of the nature of crack propagation yielded no correlation between structural characteristics and resistance to cracking caused by thermal shock.

An analysis of the manner in which the thermal-shock crack formed and progressed into the specimen, and an examination of available data on the notch impact strength of cast high-temperature alloys, indicated a possible relation between notch impact strength and resistance to cracking caused by thermal shock.

Magnetic-Fluid Clutch Developed

A mixture of oil and finely-divided iron powder which can instantly change to a solid and then return to a liquid again is the basic feature of an improved magnetic-fluid clutch announced recently by General Electric Co. When the unit is energized, the fluid solidifies to form a rigid connection between two rotary cylinders so that the motion of one cylinder is transmitted to the other. Varying degrees of rigidity of the magnetic fluid can be obtained by

NEW and EXCLUSIVE developments in induction heating...

Available in single and two-station models the Lindberg LI-25 is ideal for hardening, brazing and soldering, annealing and stress relieving, hot forming and light forging, shrink fitting and other induction heating applications.

The Lindberg LI-25 is a ruggedly constructed vacuum-tube type unit for hard working production line jobs. Oscillator tube, power transformer and other major components deliver a full 25 KW with plenty of reserve to insure dependable day in and day out performance. Well designed—safe and simple to operate—featuring the most desirable developments in high frequency heating.

CONDITIONED COOLING—Built-in to increase tube life, eliminate harmful condensation and scaling, reduce water pressure and consumption—can be used with hard water. Rubber hoses are completely eliminated.

"CHECKLITE"—a unique feature exclusive with this unit, makes servicing easier, reduces maintenance costs.

AUTOMATIC CONTROL—when job cycles are set, automatic timer controls every phase of the operation—heat, quench, fixture movement.

SAFE AND SIMPLE—both operator and operating parts are protected—filament voltages are constantly regulated—tank capacitor is hermetically sealed—work coils protected against burn out. Every unit certified to meet FCC regulations. For detailed information write for Bulletin T-1420.

For specific application information contact your local Lindberg Office, or write describing your problem in detail.

LINDBERG HIGH FREQUENCY HEATING

A DIVISION OF LINDBERG ENGINEERING CO.

2448 West Hubbard Street, Chicago 12, Illinois

News Digest

regulating the current, thus allowing the clutch to slip if necessary.

The G.E. magnetic-fluid clutch is still in the laboratory stage, and commercial possibilities have not yet been explored.

Conference to Discuss Plastics

Plastics, especially their mechanical properties, will be the subject of a three-day conference at Massachusetts Institute of Technology on June 20, 21 and 22. Sponsored by the M.I.T. Plastics Committee, the program is designed to provide an opportunity for those interested in, but not directly associated with, plastics to hear and participate in discussions of their properties and uses.

Further information can be obtained from Professor A. G. H. Dietz, Room 5-209, Massachusetts Institute of Technology, Cambridge 39, Mass.

Studies Show Metallic Friction Involves Metal Removal

Two independent investigations carried out recently by the National Advisory Committee for Aeronautics and the Massachusetts Institute of Technology shed some new light on what happens when two pieces of metal rub together.

Results of studies by Douglas Godfrey of the causes of "fretting corrosion" have been published by the NACA (*Technical Note 2039*). Fretting corrosion is the term applied to surface failure that may occur when closely fitting machine components are vibrated. It is characterized principally by surface stain, corrosion, pitting and the generation of oxides.

Aircraft Parts Failure

New incentive to solve this problem has been provided by the failure of certain aircraft parts, apparently due to fretting corrosion. Anti-friction bearings subject to rotational oscillation and side-thrust vibration experience the greatest amount of fretting corrosion, and such parts as connecting rods, knuckle pins, splined shafts, and clamped and bolted flanges suffer deleterious effects.

Glass, quartz, ruby, mica and platinum, in addition to standard metal

This is *IT* for Stainless Steel Fastenings

Over 7,000 Varieties and Sizes of Stainless Fastenings IN STOCK

Virtually every standard stainless fastening you might require is on hand in our stock bins and listed in the big, 80-page Anti-Corrosive Reference Catalog . . . called by many the "Bible of the Stainless Steel Fastening Industry."

Fingertip Index Makes Items Easy to Find; Prices Are Figured INSTANTLY

Separate sections are devoted to stainless steel machine screws, nuts, caps and bolts, wood and sheet metal screws, rivets, set screws, washers, pins and nails. In addition, each page shows list prices for all items and a quantity discount chart which makes cost estimating a simple task!

Supplementary List of Hard-to-Get Items IN STOCK; Special Alloy Section

Thousands of odd sizes and varieties in stock are found in the supplementary stock list. In addition, special sections are devoted to type 316 and other special alloys. Other items can be obtained rapidly through our special order service.

If YOU Use Stainless Steel Fastenings This Catalogue is a MUST for Your Files!

Whatever application you have for stainless fastenings, this comprehensive and authoritative reference will save you time, effort and expense. Send for your copy NOW!

Anti-Corrosive Metal Products Co., Inc. SINCE 1927

Manufacturers of STAINLESS STEEL FASTENINGS

CASTLETON ON HUDSON, NEW YORK

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alloys, were used as specimens, since their noncorrosiveness would indicate whether the primary action was physical or chemical. Fretting corrosion was induced by a simple apparatus which vibrated convex surfaces in contact with stationary flat surfaces at frequencies of 60 cycles, or less than 1 cycle per sec., an amplitude of 0.001 in., and a load of 0.2 lb.

Removal of Metal

Microscopic examination of the specimens indicated the following results and conclusions:

1. Fretting corrosion is caused by the removal of finely divided and apparently virgin material due to inherent adhesive forces.
2. The fretting corrosion of platinum, glass, quartz, ruby and mica relegates the role of oxidation as a cause to that of a secondary factor.
3. Fretting corrosion readily occurs between clean non-metals and metals.
4. Initiating of fretting corrosion is independent of vibrating motion or high sliding speeds.

Radioactive Tracing

Another investigation, by John T. Burwell, Jr., of MIT, showed that traces of metal worn from the piston rings in a gasoline engine actually can be detected forming part of the cylinder walls. The method used in this research was to make radioactive the atoms in one block of material which is to be rubbed against another. After the two blocks are rubbed together, radioactive atoms from the first block show up on the surface of the second, and tests show that they have actually become part of the second block. It is believed probable that atom transfer takes place in the other direction as well.

The same transfer effect is observed when good lubricants are used between the blocks, though on a much reduced scale. Thus, this method might prove useful for evaluating the relative effectiveness of lubricants.

The radioactive atoms of the cylinder wall can be detected with a Geiger-Muller counter. The amount of radioactivity is indicated more accurately, however, by observing the streaks left on a photographic film wrapped around the cylinder for a week or more. In this case the layer of transferred metal was less than 3.0×10^{-7} in. thick.

News Digest

Casting Process Improves Finish

A new process expected to result in castings of improved quality at lower cost is under development in this country.

Essentially, the foundry process involves use of a new resin-binder which is blended with sand and applied to the heated pattern. The resin melts, forming a continuous coating over the surface. Thus, the mold consists only of a thin shell bonded with resins, and savings of up to 90% of the sand ordinarily required are realized. The resin was developed by Bakelite Div. of Union Carbide & Carbon Corp.

Primary advantage of the castings produced by this method is their precision. The casting comes out of the mold with clean, sharp edges, true dimensions and unchilled surfaces that require little or no finishing. Tolerances of 0.002 to 0.003 in. per in. are claimed to be easily possible. (*Ed. note* — MATERIALS & METHODS will publish a feature article on this new casting process in the near future.)

Study Shows Factors Influencing Formation of Ears in Light Alloys

Factors affecting the occurrence of "ears" in the deep-drawing of aluminum and its alloys were discussed in an article by R. Chevigny, published in the British *Sheet Metal Industries* (Feb. 1950). Although there is no universal remedy for this defect, it is possible to indicate the directions in which the factors favoring formation of ears should be modified or controlled.

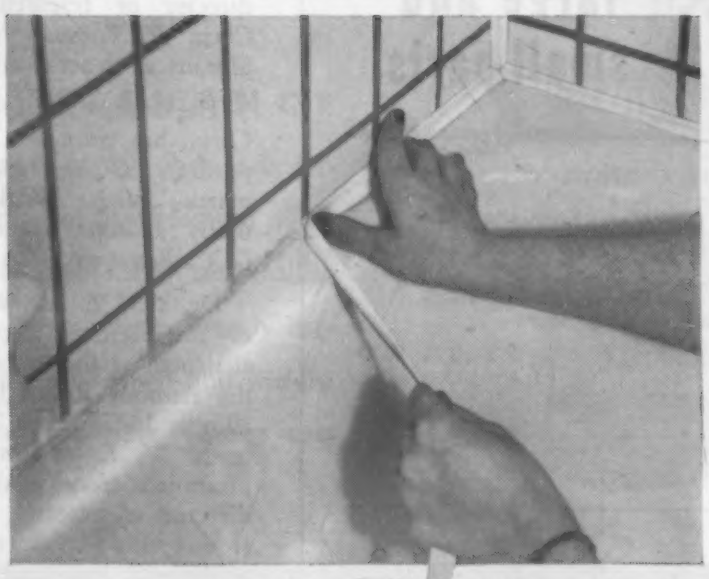
Disadvantages of Ears

Presence of "ears" raises important problems:

1. To obtain drawn shells of a given height, a larger roundel is required.
2. To bring the work into its final form, the ears must be removed.
3. Beading and edge finishing is more difficult.
4. The considerable distortion of the metal in the direction of the ears may cause tearing in that direction.

The author attributes occurrence of ears to the presence of an oriented crystalline structure in the metal. Ab-

Boon for Bathtub Splashers



"Tub-Kove" made by Keller Products, Inc., Cleveland, Ohio

ANYONE who knows the damage caused when water seeps down the crack between the bathtub and the wall will appreciate this new sealing strip made from Geon. It effectively seals cracks between wall and bathtub, washbowl, stall shower, etc., and thus prevents damage to plaster walls and woodwork. And it is easily applied by anyone in the home.

This new sealing strip is extruded from a special Geon plastic compound. It is highly flexible, will not craze or crack, and is unaffected by water. Because it is made from Geon, it will not harden and it will resist normal alkali solutions, acids and alcohols, and also soaps and detergents. Using a special cement, it adheres to porcelain, wood, clay-tile, plastic tile, and other bathroom surfaces.

This typical example of Geon's many uses may give you an idea for improving or developing a product. Geon polyvinyl materials can be extruded, compression or injection molded. They can be calendered, cast into sheets or film, or used as a coating. Products of Geon can be made resistant to cold, heat, aging, weather and wear. Colors can be brilliant or subdued, as desired.

We make no finished products — raw materials only. Write for technical bulletins or helpful service. Address Dept. GM-3, B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio. Cable address: Goodchemco.

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News Digest

sence of ears was found to occur in termediately between the formatio of ears at 45 deg. to the direction o rolling and their formation at 90 deg a slight overlay being possible be tween the two structures.

Influence of Fabrication Methods

He found that cold working o strain hardening favors the develop ment of a structure forming ears a 45-deg. orientation. Annealing sup presses the formation of ears at 4 deg. or at 90 deg., depending upo annealing temperature. Annealing th blanks or intermediate annealing fav ors the formation of ears at 90 deg the effect of an intermediate anne being particularly pronounced. Re peated annealing, however, has n appreciable additive effect.

Impurities, even in small quanti ties, have a considerable influenc on the temperatures of incipient re crystallization and thus on the eas with which ears are formed. Experi ments have shown that no one proc essing technique can reliably assur for all light alloys, the absence of ea in drawing and spinning.

News of Engineers

Gordon F. Simons has been appointe director of research of the Beryllium Corp. *W. Thomas Peterson* succeeds Mr Simons as general sales manager.

The Ingersoll Steel Div., Borg-Warne Corp., has promoted *C. M. Baker* to th position of chief engineer of the Kala mazoo, Mich. Works. Mr. Baker, for merly assistant chief engineer, succeeds *L. C. Freeman,* who recently retired.

Dr. *Carl E. Swartz,* division engineer of the Kellex Corp., has been name chairman of the Metals Research Dept. a the Armour Research Foundation of th Illinois Institute of Technology. He suc ceeds *W. E. Mahin,* who was recently promoted from chairman of metals t director of research of the Foundation It was also announced that Dr. *William R. Osgood* has joined the Foundation a a research engineer. Dr. Osgood, an au thority on the behavior of engineering materials, previously served with the Navy Dept., where he did technical liaison work between the Navy and its contractors.

The International Nickel Co., Inc. ha announced the addition of several mem

REPEAT ORDERS . . . 2 to 1 on SPENCER TURBO-COMPRESSORS

For every Spencer Turbo in service in a list of 62 large industrial plants in 1940, there were two more Spencers in service on January 1st, 1950. The horse-power of Spencer Turbos in these plants tripled in ten years.

Some of these Turbos have been operating satisfactorily for more than a quarter of a century and all of them have the well-known Spencer simplicity and reliability which is mainly responsible for such an unusual demonstration of confidence.

Design engineers appreciate the light weight, all-metal construction and the absence of noise and vibration which enable them to mount the Spencer Turbo on or under machines or overhead and out of the way. Leading furnace and oven manufacturers prefer to have the air supplied by Spencer Turbos because of their efficiency and reliability. Maintenance engineers everywhere appreciate that the wide clearances, with only two bearings to grease, means long life with extremely low maintenance costs.

LOW MAINTENANCE

Repeated analyses of repair costs indicate that the average cost of replacement parts for Spencer Turbos is less than one dollar per machine per year. This is merely another proof of the well-known and widely accepted fact that Spencer Turbos are extremely reliable.

THE AVERAGE COST FOR REPAIR PARTS IS ONE DOLLAR PER MACHINE PER YEAR

APPLICATIONS

Spencer Turbos are made in standard capacities from 35 to 20,000 cu. ft., 1/3 to 800 HP and 8 oz. to 10 lbs. pressure. The principle uses are to furnish low pressure air for oil and gas fired Heat Treating Furnaces, Foundry Cupolas, Agitation of Liquids, Gas Boosters, Engine Testing, Ventilation and Cooling.

THE SPENCER TURBINE COMPANY • HARTFORD 6, CONNECTICUT

SPENCER
HARTFORD

News Digest

bers to its Development & Research Div. *Robert E. Savage* and *Ralph W. White* have joined the Magnesium-Containing Cast Iron Section of the Division. They will make their headquarters in New York, and will work on the new Ductile Iron recently announced by the Company. Mr. Savage was an engineer in the Research Laboratory of the Carnegie-Illinois Steel Co., and Mr. White superintendent at the E. W. Bliss Co. *George H. Davis* is now associated with the Iron & Non-Ferrous Casting Section of the Division, also located in New York. He was formerly an iron foundry melter with the Ohio Steel Foundry Co.

Dr. *James T. Eaton,* manager of research, has been promoted to the position of director of research of E. F. Houghton & Co. He was also recently elected a member of the Company's Board of Directors.

Appointment of *William E. Clark* as general manager of the Engineering Works Div. of Dravo Corporation, and his election as a member of the Corporation's Executive Committee has been announced. Mr. Clark was previously general manager of the Keystone Sand & Supply Co., a pioneer Dravo company.

Herman P. Rassbach, former works manager of the Midvale Co., has joined the Electro Metallurgical Div. of Union Carbide & Carbon Corp. as metallurgical engineer with the Development Group. He will make his headquarters in Chicago. *Ralph A. Clark* has been promoted from development engineer in the Chicago office of Electro to the position of assistant manager of development in the Detroit territory. He succeeds *William B. McFerrin,* who is now division executive vice president of the Corporation's Haynes Stellite Div. in Kokomo, Ind.

Election of officers of the Riverside Metal Co. occurred recently. They include: president—*James T. Duffy, Jr.;* vice president—*Victor Ritchard;* secretary-treasurer—*L. G. Carter;* and comptroller—*H. Leon Bush.* Two new directors were also named: *Lawrence Gubb,* until recently chairman of the board of Philco Corp.; and *C. E. Dearnley,* president and treasurer of Dearnley Bros. Worsted Spinning Co., Inc.

John M. Stevenson has joined the Youngstown Sheet & Tube Co. as a development engineer in its Mill Research & Development Dept. For the present Mr. Stevenson will be located in the company's Tulsa, Okla. office, but later will be located in Dallas, Tex.

The appointment of *Walter Bonsack* as vice president and director of research of Christiansen Corp. has been announced. He will be located in the Chicago plant.

Chester W. Schweers, manager of Allis-

Meet a *LIGHT-WEIGHT* champion..

Inconel pusher trays still going strong on a job that licked heavier furnace trays!

Fabricated Inconel pusher trays carrying automobile parts through continuous heat-treating furnaces. The best life of previously-used trays averaged nine months. The fabricated Inconel trays have been in use over one year.

Inconel pusher tray designed and fabricated by BROWN-HUTCHINSON IRON WORKS, Detroit, Michigan.

- **Furnace production increased**
- **Tray life increased**
- **Maintenance costs reduced**

These substantial benefits are what a large automobile manufacturer gained by switching to fabricated Inconel* pusher furnace trays.

Previously-used trays weighed from 114 to 198 pounds each. The fabricated Inconel trays weigh only 86 pounds... a weight saving 28 to 112 lbs. per tray. Based on average net load of 400 pounds this represents a gross weight saving of 5 to 19% over previous equipment.

Even more important—these lighter-weight fabricated Inconel trays last longer, with correspondingly reduced replacement and maintenance costs.

This fine performance record is even more remarkable when the severity of service conditions are considered. During the heat-treating of automobile parts, the trays are subjected to temperatures as high as 1650° F., followed by oil quenching.

The furnaces, which are gas-fired and non-atmosphere in type, present high-temperature corrosion problems. Add to these punishing conditions the considerable mechanical forces acting on the trays... up to 540 pounds load plus 2000 pounds thrust from the hydraulic pusher mechanism... *and you have service conditions that demand Inconel plus good fixture design.*

Brown-Hutchinson Iron Works are designers and fabricators of these pusher trays. They, like other leading fabricators, specify Inconel because of Inconel's outstanding performance record and desirable combination of physical characteristics... thermal durability, corrosion-resistance, high hot and cold strength, workability, economy.

For further information about pusher trays made of Inconel, write directly to: Brown-Hutchinson Iron Works, 1831 Clay at G. T. R. R., Detroit, Mich.

*Reg. U. S. Pat. Off.

EMBLEM OF SERVICE INCO

The International Nickel Company, Inc.
67 Wall Street, New York 5, N. Y.

INCONEL*... for long life at high temperatures

News Digest

Chalmers' Los Angeles district, has be named manager of the company's Ne England region, with headquarters Boston. He succeeds *W. F. Taylor,* w resigned.

The new president of Fairbanks, Mor & Co. is *Robert H. Morse, Jr.,* grandso of the founder of the Company. M Morse, previously vice president in charg of operations, succeeds his father, Colon *Robert H. Morse,* who became chairma of the board.

The appointment of *H. H. Morgan* a general manager of the Robert W. Hun Co. has been announced. He will co tinue as vice president and chief engine

William F. Aylard recently was pr moted to the position of chief engineer Chase Brass & Copper Co., Inc. *Melv C. Harris,* formerly vice president i charge of operations of the Allegh Ludlum Steel Corp., succeeds Mr. Ayla as works manager of the Cleveland, Oh mills of Chase.

The retirement of Dr. *Nathaniel Loomis,* widely known in the field petroleum research, after 32 years service with affiliates of Standard Oil C (New Jersey) has just been announce *Eric W. Luster,* manager of the Esso E gineering Dept., succeeds Dr. Loomis vice president and a member of the boa of directors.

George H. Tulley has been promote to the position of manager of the Clev land office of Metals Disintegrating Co Inc. He will also retain his position i the company as powder sales supervis

The Baker Industrial Truck Div. of th Baker-Raulang Co. has announced th election of *Robert H. Davies* as vic president and acting general manage and *Edward H. Remde* as vice presiden

Dr. *John K. Gustafson,* former manage of the United States Atomic Energy Com mission's Raw Materials Operations offic has accepted an appointment to th Atomic Energy Commission Advisor Committee on Raw Materials. Dr. Gusta son is at present consulting geologist the M. A. Hanna Co.

The General Electric Medical Product Co. has named *Edward W. Philleo* vic president and general manager. He wa manager of the California District fo General Electric X-Ray Corp., parent or ganization.

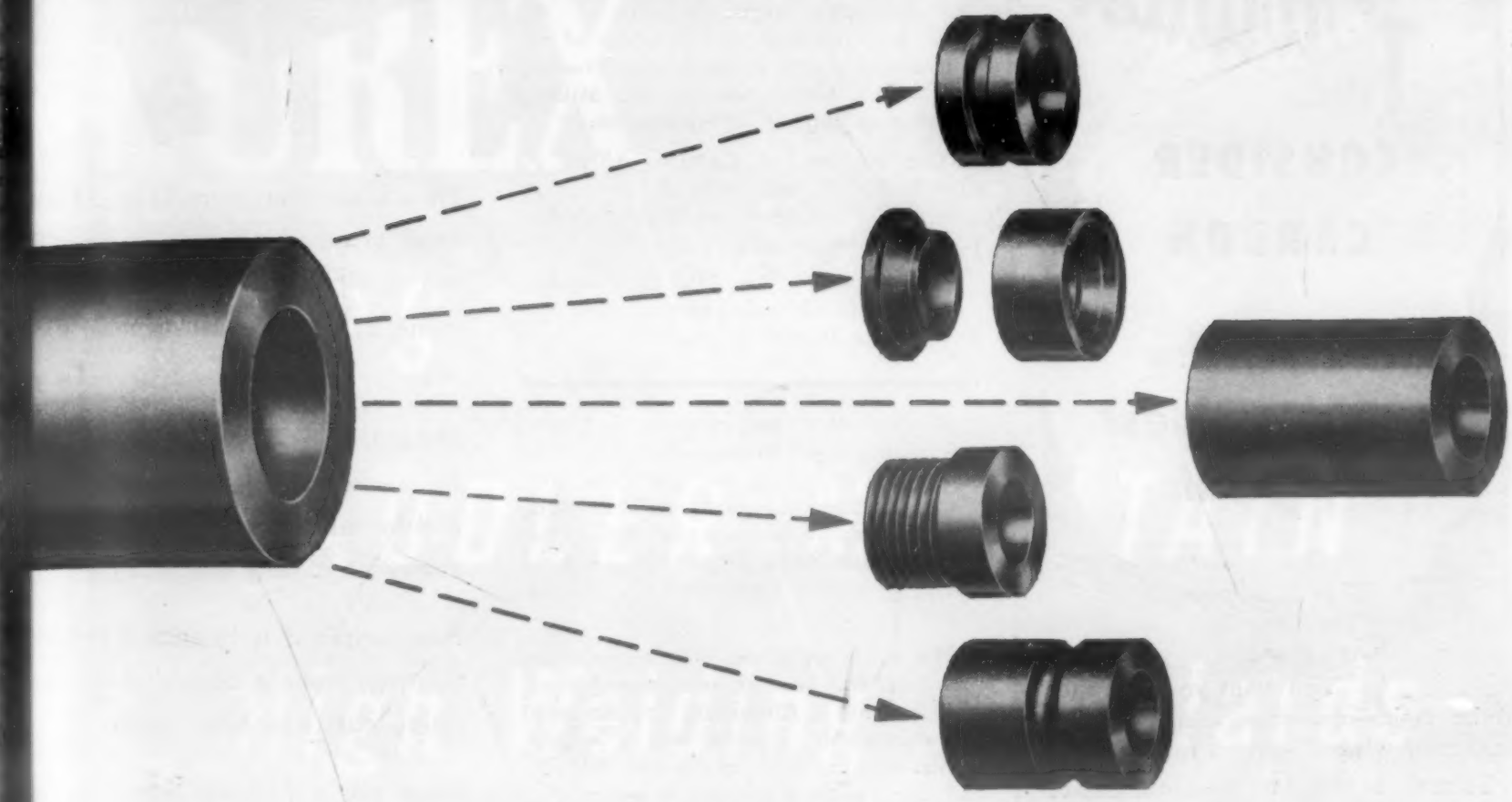
William L. Batt, president of SKF In dustries, Inc., has been elected a directo of American Standards Assn.

Reynolds Metals Co. has announced two appointments to its Aluminum Div *F. F. Tiffany,* district manager of th Company's Dayton, Ohio office, has take over the duties of division manager i the Pittsburgh area. And *T. D. Lewi*

ROCKRITE TUBING

SAVES UP TO 50%

OF MACHINING COSTS ON THESE PARTS



You may be saving money by machining parts like those shown here from ordinary mechanical tubing instead of from bar stock or forgings. But with lighter close-tolerance Rockrite Tubing, cost-saving possibilities are still greater! Here's why:

1 Rockrite Tubing is sized by a distinctively different process to much closer tolerances than are practicable by any other method.

2 Machine output has been doubled and machining costs cut in half when Rockrite was substituted for standard mechanical tubing.

ROCKRITE TUBING

LEADS ALL OTHERS IN THESE SAVINGS

- Higher cutting speeds
- Tools last longer between grinds
- Work-surface finishes are better
- Stations on automatics are often released for additional operations
- Extra-long pieces available — less downtime for magazine stocking and fewer scrap ends
- Closer tolerances often eliminate necessity for machining on outside or inside

WANT TO KNOW THE 3 REQUIREMENTS ESSENTIAL FOR TUBE ACCURACY AND COST SAVINGS? Send for new Bulletin being prepared on "behind-the-scenes" facts on close-tolerance Rockrite Tubing. TR-114

TUBE REDUCING CORPORATION · WALLINGTON, NEW JERSEY

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sales representative in the San Francisco area, is now division manager of the Atlanta office.

F. M. Gillies has resigned as works manager of the Indiana Harbor plant of the Inland Steel Co., and *A. P. Miller,* general superintendent of the plant, has been transferred to inactive status under the company's retirement plan. *F. M. Rich,* who has been vice president of the Kaiser Steel Corp. in charge of operations at Fontana, Calif., assumes Mr. Miller's position as general superintendent.

The election of Captain *Alfred F. Olivet,* USNR, and *John P. Ahrens* as directors of the American Cladmetals Co. has been announced.

Leo B. Glaser has just been named manager of the newly-formed Neg'ator Div. of the Hunter Spring Co.

Walford H. Plant, president and general manager of Brazaco, S.A., died in Sao Paulo following an operation. Mr. Plant had been associated with Brazaco, S.A., general distributor in Brazil for United States Steel Export Co., a subsidiary of United States Steel Co., for 35 years.

The death of *Frank A. Luebbe,* vice president and general sales manager of Nichols Wire & Aluminum Co., has been announced. Mr. Luebbe was a widely known sales executive in the steel industry and later in the aluminum industry.

The Bureau of Mines has announced the death of *Charles W. Davis,* chief of the Boulder City, Nev. branch of the Bureau's Metallurgical Div. Mr. Davis served with the Bureau for 34 years.

News of Companies

United Chromium, Inc. has erected new and larger research laboratories at 1700 E. Nine Mile Rd., Ferndale Station, Detroit 20, Mich.

A new office has been established by the *Bjorksten Research Laboratories* at 50 E. 41st St., New York City. The Chicago office will continue operations under the direction of Dr. Edwin L. Gustus, vice president. Dr. Johan Bjorksten, president, will divide his time between the New York office and the research laboratories of the Corporation in Madison, Wis.

Carboloy Co., Inc., Detroit, Mich., has announced the appointment of the *Erie*

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Manufacturing & Supply Corp., Erie, Pa., as an authorized distributor for Erie and the Northwestern Pennsylvania territory. Another appointment was that of *Tools & Supplies, Inc.*, St. Louis 3, Mo., as an authorized distributor for the St. Louis area.

The offices and factory of the *Soreng Manufacturing Corp.* has been moved to 9555 W. Eden Ave., Schiller Park, Ill.

Establishment of an office in Paris, France by *Southwest Research Institute*, San Antonio, Tex., and its affiliated scientific organizations to facilitate handling of work for European companies and individuals has been announced. The Paris office, directed by Servan G. Cantacuzene, research engineer, is the fourth to be established by the Texas industrial research laboratories.

E. W. Bliss Co., Toledo, Ohio, announces the appointment of the *Steel City Tool & Machinery Co., Inc.*, Pittsburgh 19, Pa., as sales representative for Bliss mechanical and hydraulic presses in portions of Western Pennsylvania and Southeastern Ohio. Coincident to this move Bliss is closing its sales office in Pittsburgh. George Vassily, sales engineer in the Bliss Pittsburgh office, has joined the Steel City sales engineering staff and will continue to service Bliss customers in this capacity.

All manufacturing and administrative activities of the *Marvel-Schebler Carburetor Div.* of *Borg-Warner Corp.*, now located in Flint, Mich., will be transferred to Decatur, Ill. in the late summer or early fall of this year.

The *Federal Machine & Welder Co.*, Warren, Ohio, has announced the appointment of *Austin-Hastings Co., Inc.*, Cambridge, Mass., as district representatives for the states of Maine, Vermont, Massachusetts, New Hampshire, Connecticut and Rhode Island.

Three annual scholarships, which cover all expenses for complete four-year courses in specified branches of engineering, are available at the Michigan College of Mining & Technology. The *Calumet & Hecla Consolidated Copper Co.*, Calumet, Mich., offers a scholarship in either mining or metallurgical engineering. The *Montreal Mining Co.*, Montreal, Wis., makes a grant for study in mining engineering. And the *Lake Shore Engineering Co.*, Iron Mountain, Mich., provides a scholarship in either mechanical or electrical engineering. All three of these awards limit eligibility to the geographical area in which the individual company

DIRECT-TO-YOU SHIPMENTS OF BRONZE BAR STOCK CUT BEARING COSTS!

Stocks of N-B-M "Tiger" Bronze now located for fast delivery of the bar size you want, when you want it.

National Bearing Division has announced a new direct-shipment policy on "Tiger" Bronze Bar Stock—a policy designed to substantially reduce costs of bearings, *used for plant maintenance or on production lines.*

Stocks have been conveniently "spotted" to assure fast delivery. All popular sizes in 13" lengths are available—as-cast or machined cored and solids, or as-cast hexagons.

Product Designers and Plant Engineers with an eye on bearing costs are urged to get the complete facts. *Inquiries receive prompt attention.*

"TIGER" BRONZE . . . the ONE Bronze Alloy with ALL these features for longer bearing service at lower cost . . .

WEAR-RESISTANT—Has correct balance between bronze matrix and lead. *Lasts longer.*

ANTI-FRICTIONAL—Low coefficient of friction helps prevent shaft seizure. *Saves power.*

SHOCK-RESISTANT, EMBEDDABLE—Hard enough to stand up under heavy bearing loads. Soft enough to embed foreign material. *Protects the shaft.*

EASY TO MACHINE—With speeds as high as 3000 F.P.M. *Saves time.*

USE THIS COUPON —*for price quotations by return mail, and new bulletin giving complete FACTS on physical properties, operating characteristics, bar types and sizes.*

Please send me your new Cored and Solid Bar Bulletin and prices on "Tiger" Bronze:

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Company .....

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We use Bronze Stock for .....

Approximate poundage used per month: .....

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News Digest

operates. None, however, has strings attached concerning employment after graduation.

News of Societies

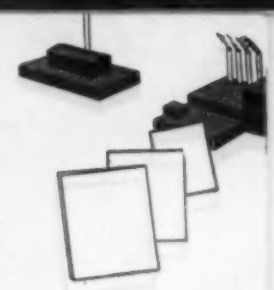
The *International Acetylene Association* elected the following officers during its recent annual convention: president—Claude E. Monlux, vice president, The Linde Air Products Co.; vice president—James W. Dunham, vice president, National Cylinder Gas Co.; re-elected secretary and treasurer, respectively—H. F. Reinhard; and E. V. David, assistant manager, Technical Sales Div., Air Reduction Sales Co.

Dr. Paul Schwarzkopf, president of the American Electro Metal Corp., was the recipient recently of the medal awarded annually by *Stevens Institute of Technology* for outstanding achievement in the field of powder metallurgy.

The *Steel Founders' Society of America* re-elected Thomas H. Shartle, president of the Texas Electric Steel Casting Co., as president of the Society. Elected as vice president was J. E. Mullen, vice president of the National Erie Corp.; and as national director and member of the three-man executive committee of the Society, G. Rhoads Casey, president and general manager of the Treadwell Engineering Co. National medal awards were also presented at the Society's annual meeting. A. J. McDonald, vice president of American Steel Foundries, received the Society's top award, the Lorenz Memorial Gold Medal, in commemoration of outstanding service to the industry. John F. Lacey, works manager of the Commercial Steel Casting Co., was the recipient of the Society's Technical and Operating Medal for 1949. And S. F. Carter, assistant melting superintendent of the American Cast Iron Pipe Co., was presented with the annual *Steel Foundry Facts* prize award, for excellence of material published in the Society's technical periodical.

Robert H. Brown, chief of chemical metallurgy at the Research Laboratories of the Aluminum Co. of America, has been chosen by the *National Association of Corrosion Engineers* to receive the Whitney Award for 1950, in recognition of his outstanding contributions to the science of corrosion. The Whitney Award is international in scope, and is one of the highest honors in the field of corrosion engineering.

(More News on page 166)



MANUFACTURERS' LITERATURE

Materials

Iron • Steel

Corrosion-Resisting Steel. Bethlehem Steel Co., 52 pages, illustrated, No. 259. Comprehensive discussion of properties and characteristics of Mayari R, a low-alloy steel for applications requiring light weight, high strength and increased corrosion resistance. Also contains design data and application information. (1)

Alloy Steels. Carpenter Steel Co., 14 pages. Describes properties and fabricating characteristics of two chromium-nickel grades, Carpenter No. 158 and 5-317, which can be used for all applications requiring alloy steels. (2)

Steel Design. Climax Molybdenum Co., 72 pages. Reviewed previously. Booklet entitled "3 Keys to Satisfaction" tells how to combine good design, high quality steel and proper treatment for best results. (3)

Tool Steel Selector. Crucible Steel Co. of America. Circular, 9-in. dia. selector picks out correct tool steel for given applications and gives information on proper heat treatment. (4)

High-Strength, Low-Alloy Steel. Jones & Laughlin Steel Corp., 32 pages, illustrated. Complete technical data on Otiscoloy, a high-strength, low-alloy steel widely used in the transportation industry. Many applications pictured. (5)

Machining Stainless Steels. Joslyn Manufacturing & Supply Co., 4 pages. Table lists recommended machining rates for various fabricating operations on the different grades of stainless steel. Also general information on machining characteristics of stainless. (6)

Steel Bars. La Salle Steel Co. Reviewed previously. How Stressproof cold-finished carbon steel bar cuts costs because of its strength, machinability, wearability and minimum warpage. (7)

Two Alloy Steels. Joseph T. Ryerson & Son, Inc., 4 pages. Engineering data on two alloy steels, Rycrome and Nikrome "M", supplied in heat treated condition for heavy-duty axles and shafts, gears and pinions, studs and bolts, etc. (8)

Steel Stock List. U. S. Steel Supply Co., 208 S. La Salle St.. Chicago 4, Ill. 1950-51 Stock List & Reference Book lists readily available stocks of steel, aluminum, tools and machinery, and provides facilities for computation of up-to-minute prices. Free when requested from U. S. Steel Supply Co. on company letterhead.

Nonferrous Metals

Aluminum Bronze. Ampco Metal, Inc. Complete catalog of aluminum bronze alloys, including physical properties. Rolled sheet and plate, sand and centrifugal castings, forgings, extrusions, welding electrodes, etc. (9)

Beryllium Copper. The Beryllium Corp., 4 pages, No. 13. How to order beryllium copper rod, bar and wire. Describes alloy, condition and temper, and gives mill sizes and mechanical and electrical properties. (10)

Special Nonferrous Alloys. Driver-Harris Co., 4 pages, illustrated, *D-H Alloy Craftsman,* Vol. 10, No. 1. Pictures and describes variety of actual applications for strip and wire of nickel, Inconel, Monel and Nichrome alloys furnished by this company. (11)

High-Strength Alloys. Haynes Stellite Div., Union Carbide & Carbon Corp., 40 pages, illustrated. Describes the four Hastelloy high-strength, nickel-base, corrosion-resistant alloys. Gives mechanical properties, corrosion resistance, available forms and fabrication procedures. (12)

Bronze Bars. National Bearing Div. of American Brake Shoe Co., 6 pages, illustrated. Reviewed previously. Catalog gives sizes and approximate weights of as-cast and machined cored and solid bars of N-B-M "Tiger" Bronze. Properties and advantages cited. (13)

New Metals. Tempil Corp., 1 page, *Tempil Topics,* Vol. 5, No. 2. Brief discussion of new engineering metals—molybdenum, titanium and zirconium—and tabular comparison of their properties with those of older metals and alloys. (14)

Brass Price Calculator. Volco Brass & Copper Co., Kenilworth, N. J. Slide-window type calculator shows prices of principal copper alloys in strip and wire of various gages. Free to executives when requested from Volco on company letterhead.

Nonmetallic Materials

Ceramics. American Lava Corp., 4 pages, illustrated, No. 501. Table of mechanical and electrical properties of 17 AlSiMag ceramics. (15)

Polystyrene Plastic. American Molding Powder & Chemical Corp., 4 pages, illustrated. Properties of Ampacet polystyrene molding powder. Describes standard and special colors available. (16)

Molding Compounds, Bonding Resins. The Borden Co., Chemical Div., 8 pages, illustrated. Advantages and applications of Durite phenolic thermosetting molding compounds, industrial bonding resins and cements. (17)

Plywood. Douglas Fir Plywood Assn., 32 pages, illustrated. Series of articles show how to use plywood effectively in fixtures, displays, posters and signs. (18)

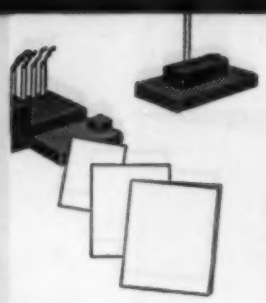
Plastics. E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Dept., 12 pages, illustrated. Working techniques, properties and uses of plastics made from Polythene, Nylon, Teflon, Lucite and other molding powders. Also extensive table of mechanical, electrical, thermal and optical properties. (19)

Resins. Goodyear Tire & Rubber Co., Inc., Chemical Div., 12 pages, Techni-Guide No. PV-1. Complete technical data on three Pliovic vinyl chloride copolymers. Information on plasticizers, stabilizers, fillers, colors, release agents, processing methods and applications. Suppliers listed. (20)

Plastic Laminates. Owens-Corning Fiberglas Corp., 36 pages, illustrated. Properties and uses of laminates and plastics parts made with Fiberglas reinforcements. Also data on Fiberglas-base electrical insulating materials. (21)

Resins, Plasticizers. Rohm & Haas Co., Resinous Products Div., 4 pages. Recent news on use of this company's resins and plasticizers for coatings and plastic products. (22)

To obtain literature appearing on these pages, please refer to easy-to-use reply card on page 163.



MANUFACTURERS' LITERATURE

Parts • Forms

Aluminum Die Castings Design. Aluminum Co. of America, Pittsburgh 19, Pa., 189 pages, illustrated. Price $1.00. Aimed at buyer of light-metal die castings. Data on die casting process and equipment, alloys used, design rules, and finishing and machining considerations. Requests should be sent directly to the Aluminum Co.

Mechanical Tubing. Babcock & Wilcox Tube Co., 4 pages, illustrated, No. TB-324. Advantages of this company's mechanical tubing for structural parts. Lists available types, steel analyses, sizes, surface finishes, conditions and shapes. (23)

Stainless Tubing. Carpenter Steel Co., Alloy Tube Div., 4 pages, illustrated. Physical properties, corrosion resistance and available sizes of this company's stainless steel tubing. (24)

Wire Gage Chart. Central Steel & Wire Co., 3000 W. 51 St., Chicago 80. Wall-type gage chart for ferrous and nonferrous flat rolled wire. Free when requested from Central on company letterhead.

Threaded Part Design. Eastern Machine Screw Corp., 4 pages, illustrated, *Die Headlines,* Vol. 3, No. 7. Contains cost-reducing suggestions on design of threaded parts. Also gives selection table for thread sizes. (25)

Glass Pipe, Fittings. Fisher & Porter Co., 4 pages, illustrated, No. 94. Advantages of glass pipe and fittings for corrosive fluids. Specifications given. (26)

Ceramic Parts. General Ceramics & Steatite Corp., 12 pages, illustrated, No. CHE-R3. Describes types of standard ceramic fittings available, and indicates this company's facilities for supplying custom engineered parts and assemblies. (27)

Precision Castings. Gray-Syracuse, Inc., 4 pages, illustrated. Reviewed previously. Shows various small parts precision-cast of brass, bronze, beryllium, copper, and carbon, stainless, tool and high-temperature steels. (28)

Molded Plastics. The Grigoleit Co. Folder describes this company's facilities for producing molded plastics. Includes designing, engineering, tooling, molding and finishing. (29)

Springs. Hunter Spring Co., 4 pages, illustrated. Detailed description of this company's facilities for producing wide variety of extension, compression and torsion springs and wire forms. (30)

Stainless Steel Castings. Lebanon Steel Foundry, 4 pages. Reference chart on designations, analyses, physical properties and heat treatments for 18 stainless, corrosion- and heat-resistant alloy steels cast by this company. (31)

Forgings and Pressings. Lenape Hydraulic Pressing & Forging Co., 60 pages, illustrated, No. 9-49. Catalog of welding necks, manways, curved nozzles and pads and miscellaneous forged and press-formed parts. (32)

Plastic Moldings. Loma Plastics, Inc., 4 pages, illustrated. Shows typical parts produced on order as plastic moldings and describes this company's facilities for such work. (33)

Iron Castings. Meehanite Metal Corp., 4 pages, illustrated, No. 32. Reviewed previously. Detailed tabular summary of physical properties of Meehanite high quality gray iron castings. (34)

Carbon Products. Morganite, Inc., 8 pages, illustrated, No. lf. Reviewed previously. Specifications of various types of carbon bearings and bushings. Also lists properties and general characteristics of the six different series of Morganite carbon products. (35)

Zinc Alloy Die Castings. New Jersey Zinc Co., 28 pages, illustrated. Principal features of Zamak-3 and Zamak-5 zinc alloy die castings, their method of production, and typical applications. (36)

Plastic Ring Gaskets. Plastic Engineering & Sales Corp., illustrated. Folder describes nature and applications of Pesco plastic ring seal gaskets, molded from Fiberglas and special synthetic resins. (37)

Plastics Fabrication. Regal Plastic Co., 8 pages, illustrated. Pictures typical plastic parts engineered and fabricated by this company on order. (38)

Aluminum Parts, Assemblies. Reynolds Metals Co., Industrial Parts Div. Reviewed previously. Discusses complete aluminum fabrication service which supplies parts and assemblies to many production lines. Information on plants, and type and range of equipment and services available. (39)

Plastics Forms. Rogers Corp., 12 pages, illustrated. Catalog of materials and services available. Two molding compound series described. Forms include molding boards, laminated sheets and punchings, and preshaped preforms. (40)

Roll-Formed Shapes. Roll Formed Products Co., 8 pages, illustrated. Describes facilities for engineering and producing roll formed shapes from ferrous and nonferrous alloys. (41)

Steel Casting Design. Steel Founders' Society of America, 7 pages, illustrated. Discusses fundamentals of steel casting design and evaluates steel castings in comparison with weldments, forgings and riveted assemblies. (42)

Extruded Shapes. Titan Metal Manufacturing Co., 4 pages, illustrated. Chemical composition and physical properties of brasses and bronzes extruded by this company. Typical parts and forms shown. (43)

Powdered Metal Parts. The Wel-Met Co., 4 pages, illustrated, No. 103. Case histories for 25 different machine parts fabricated by this company from metal powders. Gives material, former fabrication method and advantages gained by change. (44)

Coatings • Finishes

Colloidal Graphite. Acheson Colloids Corp., 4 pages, illustrated, No. 432. Describes use of colloidal graphite for coatings on glass, ceramics and metals for electronic applications. (45)

Chemical Analysis of Finishes. Azed, Inc., 18 pages. Detailed procedures for chemical analysis of this company's products for protecting and decorating zinc or steel surfaces. (46)

Aluminum Coating. Bisonite Co., Inc., 1 page. Advantages of BiChem "R," an aluminum coating for metals suitable for production line handling. (47)

Finishes. Brooklyn Varnish Manufacturing Co., Inc., 4 pages, illustrated, *The Coating Corner,* Vol. 3, No. 2. Discusses applications of Tuf-On finishes in various fields, and compares performance with that of other finishes. (48)

Rhodium. Sigmund Cohn Manufacturing Co., 4 pages. Discusses general properties of rhodium and its usefulness as an electroplate resulting from whiteness, hardness, high reflectivity and corrosion resistance. (49)

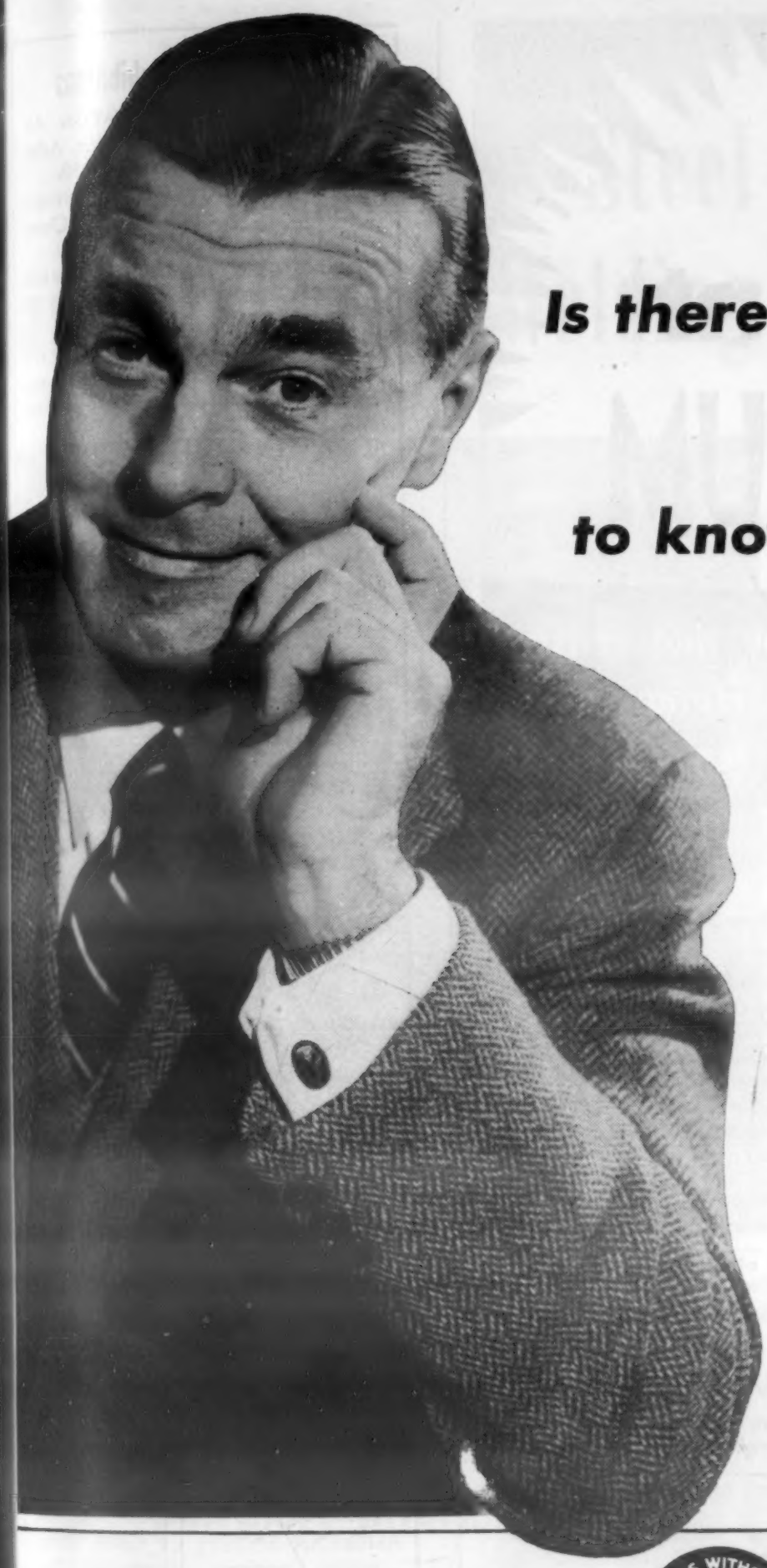
Protective Coatings. Corrosite Corp., 5 pages. Advantages and applications of Corrosite protective coatings for metals, with detailed instructions on use. Also included are sample color panels and product endorsements. (50)

Chromium Chemicals. Diamond Alkali Co., 300 Union Commerce Bldg., Cleveland 14, Ohio, 32 pages. Includes discussion of bichromate solutions as "red dip" treatment for brass and other copper-base alloys, and as corrosion-resistant treatment of magnesium, tin plate and aluminum. Free when requested from Diamond Alkali on company letterhead.

Inorganic Colors. Ferro Enamel Corp., 28 pages, illustrated. Folder describes large variety of pigments available for plastics, rubber, lacquers, enamels, paints, etc. Color selection table included. (51)

Wrinkle Finishes. New Wrinkle, Inc., illustrated. Reviewed previously. Folder showing typical products utilizing Wrinkle finishes. (52)

Enamels. The Sherwin-Williams Co., 12 pages plus samples. Describes Dimenso enamels and their application. Also contains sample color panels and transparencies of typical products, making it possible to test the appearance of the various enamels. (53)



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COLUMBIA STEEL COMPANY, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
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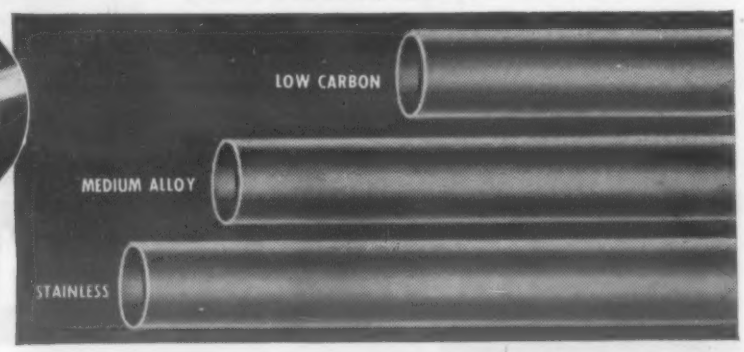

USS **NATIONAL *Seamless* PIPE AND TUBING**

UNITED STATES STEEL

Meetings and Exhibitions

NATIONAL DISTRICT HEATING ASSOCIATION, annual meeting. Asheville, N. C. May 23-26, 1950.

SOCIETY FOR EXPERIMENTAL STRESS ANALYSIS, spring meeting. Cleveland, Ohio. May 25-27, 1950.

CANADIAN INTERNATIONAL TRADE FAIR. Toronto, Canada. May 29-June 9, 1950.

AMERICAN SOCIETY FOR QUALITY CONTROL, national convention and Midwest conference. Milwaukee, Wis. June 1-2, 1950.

ELECTRIC METAL MAKERS GUILD, annual meeting. Springfield, Ohio. June 1-3, 1950.

AMERICAN SOCIETY OF REFRIGERATING ENGINEERS, semi-annual meeting. Kansas City, Mo. June 4-7, 1950.

SOCIETY OF AUTOMOTIVE ENGINEERS, summer meeting. French Lick, Ind. June 4-9, 1950.

AMERICAN GEAR MANUFACTURERS ASSOCIATION, annual meeting. Hot Springs, Va. June 5-7, 1950.

NATIONAL ASSOCIATION OF PURCHASING AGENTS, annual convention. Cleveland, Ohio. June 12-14, 1950.

AMERICAN ELECTROPLATERS' SOCIETY, annual convention and international electrodeposition conference. Boston, Mass. June 12-15, 1950.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Oil & Gas Power Div. conference. Baltimore, Md. June 12-16, 1950.

AMERICAN SOCIETY FOR ENGINEERING EDUCATION, annual meeting. Seattle, Wash. June 19-23, 1950.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, semi-annual meeting. St. Louis, Mo. June 19-23, 1950.

MALLEABLE FOUNDERS' SOCIETY, annual meeting. Hot Springs, Va. June 22-23, 1950.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Applied Mechanics Div. conference. Lafayette, Ind. June 22-24, 1950.

AMERICAN SOCIETY FOR TESTING MATERIALS, annual meeting. Atlantic City, N. J. June 26-30, 1950.

AMERICAN SOCIETY OF CIVIL ENGINEERS, summer convention. Toronto, Canada. July 12-14, 1950.

INSTITUTE OF THE AERONAUTICAL SCIENCES, annual summer meeting. Los Angeles, Calif. July 12-14, 1950.

UNITED STATES INTERNATIONAL TRADE FAIR. Chicago, Ill. Aug. 7-19, 1950.

SOCIETY OF AUTOMOTIVE ENGINEERS, West Coast meeting. Los Angeles, Calif. Aug. 14-16, 1950.

AMERICAN CHEMICAL SOCIETY, national meeting. Chicago, Ill. Sept. 3-8, 1950.

NATIONAL CHEMICAL EXPOSITION. Chicago, Ill. Sept. 5-9, 1950.

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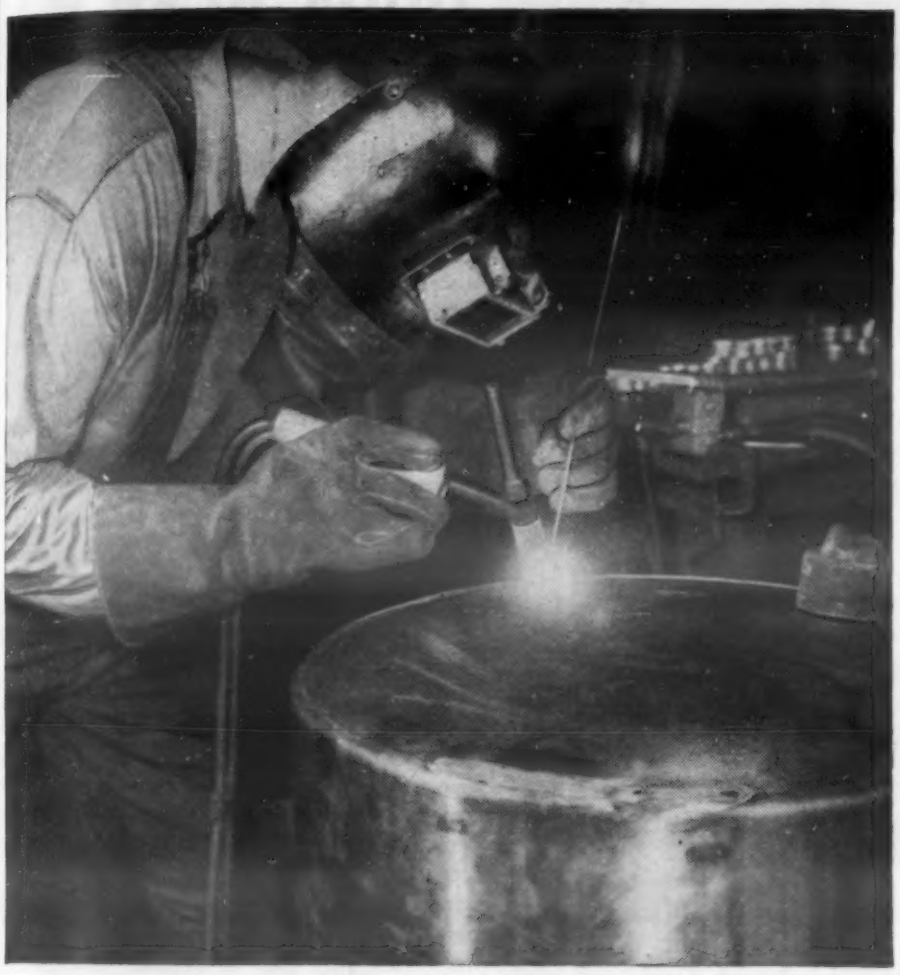

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BOOK REVIEWS

Casting Design and Production

FUNDAMENTALS IN THE PRODUCTION AND DESIGN OF CASTINGS. *By Clarence T. Marek. Published by John Wiley & Sons, Inc., New York 16, N. Y., 1950. Cloth, 5¾ by 8½ in., 383 pages. Price $4.00.*

The title of this book is a good description of its contents. For the author is concerned not just with molding, pouring and finishing procedures in the foundry, but primarily with the relation of casting design to economical production. His premise is that the design engineer has the dual responsibility of designing a part so that it will perform a certain function and so that it can be produced with the least expenditure of labor and material.

After considering the general features of the various casting processes available, the author discusses in order: green sand molding; foundry sands and sand control; patterns and related equipment; cores and their applications; foundry production equipment; production planning; physical and metallurgical properties of cast metals; properties and uses of ferrous cast metals; properties and uses of nonferrous cast metals; melting of cast metals; and cleaning and inspection. His final chapters, covering design for economical molding and design to eliminate defects, represent practical application of the information presented in the earlier parts of the book.

The reader should not expect a foundry handbook. He may wish for more detailed information on the effects of varying sand composition on the castings produced. Certainly the treatment of casting alloys is somewhat superficial. However, such information is readily available elsewhere and is not essential to the author's purpose. There may also be some quarrel with the chapter organization of the book. But there can be no quarrel with the overall usefulness of this readable and well-illustrated text, which provides the engineer with a clear understanding of the problems to be considered in designing a part as a casting.

Other New Books

TRANSACTIONS OF THE ELECTROCHEMICAL SOCIETY, VOLUME 94. *Published by the Electrochemical Society, Inc., New York 25, N. Y., 1948. Cloth, 6¼ by 9¼ in., 429 pages. Price $7.00.* All the papers presented at the annual convention of the Electrochemical Society, held in New York City on Oct. 13-16, 1948, are included.